

Comparative Outcomes of Elastic Stable Intramedullary Nailing vs. Plate Fixation in Pediatric Femoral Shaft Fractures. A Prospective Study

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SUMMARY

Background. Pediatric femoral fractures are common in emergency rooms, with treatment options varying by age. This study compares elastic stable intramedullary nailing (ESIN) and plate fixation for diaphyseal femoral fractures in children aged 5-10.

Material and methods: Conducted at Al-Kindi Teaching Hospital, Baghdad, from December 2017 to December 2019, this prospective study included 32 children with closed transverse diaphyseal femoral fractures. Patients were divided into two groups: 16 treated with ESIN (Group 1) and 16 with plate fixation (Group 2). Criteria excluded comminuted, open, or pathological fractures.

Results. Group 1 had a mean age of 7.1 years and weight of 23.7 kg; Group 2 had a mean age of 7.8 years and weight of 30.9 kg. ESIN resulted in shorter operative times (58.4 minutes), earlier weight-bearing, and quicker fracture union (8.8 weeks) compared to plate fixation (76.3 minutes, 11.9 weeks). Blood loss was significantly less in Group 1 (32.8 ml) versus Group 2 (205.0 ml). No significant differences in wound healing or leg length discrepancies were observed.

Conclusions. 1. Our study indicates a preference for Elastic Stable Intramedullary Nailing (ESIN) over plate fixation for pediatric femoral shaft fractures in children aged 5-10 years. 2. ESIN is associated with shorter operative times and faster commencement of weight-bearing, critical in pediatric recovery. 3. While ESIN is generally preferable, plate fixation may be better suited in certain clinical scenarios, emphasizing the importance of personalized treatment. 4. Based on our findings, ESIN is recommended for treating transverse diaphyseal femur fractures in the specified pediatric age group. 5. Recommends further studies, including randomized controlled trials, for a more comprehensive understanding of these treatments' long-term outcomes.

Key words: femur fracture, diaphysis, elastic nail, compression plate, outcomes

BACKGROUND

Diaphyseal fractures of the lower limb's long bones are a frequent occurrence in pediatric traumatology, posing significant challenges in clinical management and economic burden. Among these, femoral fractures are notably prevalent, often requiring hospitalization and representing one of the most substantial costs in pediatric trauma care. The complexity of treating these fractures is compounded by the diverse physiological characteristics of the pediatric population, where the age, weight, and stature of the child significantly influence the choice of treatment.

Historically, the management of pediatric femoral fractures has evolved from conservative casting methods to more invasive surgical interventions, reflecting a continual quest for improved outcomes and minimized trauma. Intra-Medullary Nailing, specifically Elastic Stable Intramedullary Nailing (ESIN), has gained prominence due to its minimally invasive nature, cost-effectiveness, and satisfactory alignment outcomes. ESIN is lauded for its reduced operating times and lower incidences of blood loss, making it a preferred choice for many practitioners [1-4]. However, despite its benefits, ESIN is not devoid of complications. Issues such as nail protrusion, pain at the insertion site, and higher rates of unplanned surgeries and malunions have been documented fueling ongoing debates about the most efficacious and safe treatment modalities [5].

On the other hand, Submuscular Bridge Plating, a technique less invasive than traditional plating, has been proposed as a viable alternative, especially for length-unstable fractures, heavier children, or those with smaller femoral canals [6-9]. While this method addresses some limitations associated with ESIN, it introduces its own set of complexities, including implant removal challenges and a steep learning curve [9-11].

This study aims to delve into this clinical conundrum by evaluating the functional outcomes in pediatric patients with diaphyseal femoral fractures treated with either ESIN or plate fixation. By comparing these two prevalent treatment methods, this research endeavours to shed light on their respective efficacies, informing and guiding orthopaedic surgeons in their decision-making process to ultimately enhance patient care in pediatric traumatology".

MATERIALS AND METHODS

Study Design and Setting: A prospective, comparative study was conducted from December 2017 to December 2018 at the Department of Orthopedic Surgery, Al-Kindi Teaching Hospital. This study aimed to provide a rigorous evaluation of the outcomes associated with two different surgical interventions for pediatric femoral diaphyseal fractures.

Participants: The study sample comprised 32 patients with transverse displaced diaphyseal fractures of the femur, with 13 females and 19 males. Participants were randomly divided into two treatment groups:

- Group A (16 patients): Underwent closed reduction and elastic nail fixation.
- Group B (16 patients): Received open reduction and plate fixation using a 3.5 dynamic compression plate.

Inclusion Criteria

- Age between 5-9 years.
- Transverse displaced diaphyseal fracture of the femur (classified as 2.2.A according to AO).
- Isolated closed femoral shaft fracture.
- Fracture occurred within the past week.

Exclusion Criteria

- Open fractures.
- Multiple fractures in a limb or more.
- Active infections.
- Pathological fractures.

Materials Used

Elastic Nail: Stainless steel nails with diameters of 2.5, 3, 3.5, 4mm, predominantly using 3 mm for this study. Nails were designed with a tip to facilitate insertion and slide through the medullary canal, with end caps available to minimize soft tissue irritation.

Dynamic Compression Plate: Varied lengths of 3.5 dynamic compression plate were used according to the individual needs of the patient.

Procedures: Patients underwent comprehensive assessments in the emergency room to rule out additional injuries. The fractures were evaluated using X-rays of the entire femur. Preoperative preparations included medical assessments and investigations for surgical fitness. Surgery was performed under antibiotic prophylaxis and general anesthesia. Detailed descriptions of the surgical techniques for both Group A and Group B are provided, illustrating the specific approaches and fixation methods employed.

Follow-up and Evaluation: Patients were followed up at intervals (2, 4, 6, 8, 10, and 12 weeks) to monitor parameters like operative time, blood loss, union time, weight-bearing capacity, and complications. Union was assessed based on the absence of pain and fracture stability, supported by radiographs. Knee Society Score (KSS) was also employed for functional assessment [12-14].

Statistical Analysis: Data were processed using SPSS version 42 and Microsoft Excel. Descriptive statistics (means, standard deviations, frequencies) were calculated for quantitative data. Inferential statis-

tics, including the chi-square test and Student's t-test, were employed as appropriate. A p-value less than 0.05 was considered statistically significant.

RESULTS

1. Demographics: Our study assessed two distinct groups, focusing on their preoperative characteristics, intraoperative parameters, and postoperative functions (Tab. 1).

Age: Group 1 (ESIN) reported a mean age of 7.1±1.4 years (range 5-9 years), while Group 2 (Plates) had an average age of 7.8±1.2 years (range 6-9 years). Statistical analysis confirmed no significant difference in age distribution between the groups (p=0.115)

Gender Distribution: Group 1 comprised 9 males and 7 females, and Group 2 consisted of 10 males and 6 females. The gender distribution was found to be balanced between the two groups (p=0.719).

Weight: Group 1 patients had an average weight of 23.7±4.6kg, significantly lighter than Group 2's

average of 30.9±6.3kg, indicating variations in the weight profile of the two groups (p<0.001).

2. Injury Characteristics: The affected side and injury cause were closely observed and found to be evenly distributed across both groups. No significant bias or preference was noted between the groups regarding these factors (p= 0.157) (Tab. 2).

3. Surgical Outcomes (Tab. 3):

Operative Time: Group 1 experienced significantly shorter surgeries (58.4±16.5 minutes) compared to Group 2 (76.3±8.1 minutes), indicating different operative times between the treatment modalities (p< 0.001).

Blood Loss: Group 1 patients lost significantly less blood (32.8±11.1cc) compared to Group 2 (205.0±42.9cc), reinforcing the differences in surgical invasiveness (p<0.0001).

4. Postoperative Outcomes (Tab. 3):

Wound Complications: Skin irritation around the nail entry site was observed in five patients from Group 1, subsiding post nail removal. Group 2 exhibi-

Tab. 1. The mean (±SD) difference of age, gender, and weight among two groups

		Elastic nail (n=16)	DCP (n=16)	P value
Age (years)	5	3(18.8%)	-	
	6	3(18.8%)	3(18.8%)	
	7	3(18.8%)	3(18.8%)	
	8	4(25.0%)	4(25.0%)	
	9	3(18.8%)	6(37.5%)	
	Mean±SD (Range)	7.1±1.4 (5-9)	7.8±1.2 (6-9)	0.115
Gender	Male	9(56.3%)	10(62.5%)	0.719
	Female	7(43.8%)	6(37.5%)	
Weight (Kg)	<20Kg	3(18.8%)	-	
	20---29	12(75.0%)	8(50.0%)	
	30---39	1(6.3%)	6(37.5%)	
	=>40Kg	-	2(12.5%)	
	Mean±SD (Range)	23.7±4.6 (16-30)	30.9±6.3 (22-45)	0.001*

*Significant difference between two independent means using Students-t-test at 0.05 level

Tab. 2. Difference of affected side and mechanism of injury among two groups

		Elastic nail (n=16)	DCP (n=16)	P value
Side	Right	6(37.5%)	10(62.5%)	0.157
	Left	10(62.5%)	6(37.5%)	
Mechanism of injury	Fall	8(50.0%)	8(50.0%)	-
	RTA	8(50.0%)	8(50.0%)	

Tab. 3. The mean (±SD) difference of operative time, time to union, time of partial and full weight bearing, wound complication, and painful hardware among two groups

		Elastic nail (n=16)	DCP (n=16)	P value
Operation time (min).		58.4±16.5 (40-90)	76.3±8.1 (65-90)	0.001*
Time to union (weeks)		8.8±1.1 (8-12)	11.8±1.3 (10-14)	0.0001*
Time of partial weight bearing (week)		4.0±1.0 (3-6)	5.4±1.4 (4-8)	0.003*
Time of full weight bearing (week)		8.8±0.9 (8-11)	11.9±3.0 (10-19)	0.0001*
Wound healing complication	Yes	5(31.2%)	5(31.3%)	-
	No	11(68.8%)	11(68.8%)	
Painful hardware	Yes	6(37.5%)	3(18.7%)	0.238
	No	10(62.5%)	13(81.3%)	

Data were presented as Mean±SD (Range)

*Significant difference between two independent means using Students-t-test at 0.05 level

Tab. 4. The mean (\pm SD) difference of KSS and LLD among the two groups

		Elastic nail (n=16)	DCP (n=16)	P value
KSS score	Poor (50-59)	1(6.3%)	4(25.0%)	0.260
	Fair (60-69)	5(31.2%)	4(25.0%)	
	Good (70-79)	3(18.7%)	5(31.3%)	
	Excellent (80-100)	7(43.8%)	3(18.7%)	
	Mean \pm SD (Range)	74.3 \pm 11.9 (55-90)	67.8 \pm 11.7 (50-90)	
LLD	Yes	5(31.2%)	2(12.5%)	0.200
	No	11(68.8%)	14(87.5%)	
Intra-operative blood loss (cc)		32.8 \pm 11.1 (20-55)	205.0 \pm 42.9 (140-320)	0.0001*

*Significant difference between two independent means using Students-t-test at 0.05 level

ted varied complications, including superficial infections and skin erythema. However, no statistically significant difference was observed between the groups in the incidence of wound complications ($p=0.238$).

Hardware Discomfort: Six patients in Group 1 reported post-operative discomfort related to surgical hardware, compared to three in Group 2, with no significant difference found between the groups ($p=0.260$).

Weight Bearing & Union: The time to initiate partial and full weight-bearing was significantly shorter in Group 1, favoring the elastic nail method ($P=0.003$ and $p<0.0001$, respectively). Similarly, Group 1 achieved fracture union quicker ($p<0.0001$).

5. Functional Outcomes (Tab. 4):

KSS Score: Group 1 had an average Knee Society Score of 74.3 ± 11.9 , compared to 67.8 ± 11.7 in Group 2. While there was a noticeable difference in mean values, it did not translate to a statistically significant difference between the groups ($p=0.129$) [15].

LLD Observations: Limb length discrepancy post-operation was noted in five patients from Group 1 and two from Group 2, with no statistically significant difference observed between the groups ($p=0.200$).

DISCUSSION

Our investigation provides an comparison between two prominent therapeutic approaches for femur fractures in a pediatric population: Elastic Stable Intramedullary Nailing (Group 1) and plate fixation (Group 2). This prospective study, conducted in a specific age group where optimal treatment is debated, offers an evaluation of various factors, from patient demographics to postoperative outcomes and complications, thus contributing to a holistic understanding of the treatment's efficacy.

Age and Gender Distribution: In terms of age, patients in Group 1 exhibited a mean age of 7.1 ± 1.4 years, while those in Group 2 averaged 7.8 ± 1.2 years. Although our findings suggested no marked age difference between the groups, this aligns with Yi Luo et al.'s research [16]. Importantly, our study further contextualizes these findings within the pediatric de-

mographic, emphasizing the nuanced considerations required when treating this age group. Similarly, the gender distribution in our study did not show a significant disparity (p value- 0.719), which is consistent with Angad Jolly et al., suggesting that treatment outcomes are broadly applicable across genders [17].

Weight Considerations and Operative Duration: Our data revealed a discernible variance in weight the groups, with Group 1 patients being lighter. This significant distinction in weight (P value 0.001) finds corroboration in Yi Luo et al.'s study and highlights the importance of considering physical parameters when choosing the most appropriate treatment modality [16]. Moreover, Group 1's shorter operative time not only aligns with the findings from Bopst L and Abbott MD's studies but also resonates with the observations from Ul Haq et al., emphasizing the efficiency of ESIN in the clinical setting [18-20].

Postoperative Outcomes and Complications: Our analysis further indicated a faster bone union and earlier initiation of weight-bearing in Group 1, a finding that is pivotal when considering the rapid growth and healing potential in children. This advantage of ESIN in promoting quicker recovery is supported by Caird et al., Ligier et al. and Hu et al., highlighting its potential benefits over plate fixation in certain scenarios [21,23]. Moreover, while our study detected wound-healing complications in a few patients from each group, the nature and severity of these complications varied. This complexity in postoperative outcomes underscores the need for a personalized approach to treatment, considering both the immediate and long-term implications for the patient's health and well-being.

Blood Loss and Clinical Implications: Significantly, Group 1 patients experienced considerably less blood loss compared to Group 2 (p value- 0.0001), a finding that parallels Yi Luo et al. and is further supported by Hu et al. [16, 23]. This reduced blood loss with ESIN is particularly crucial in pediatric patients, where minimizing intraoperative risks is of utmost importance. Clinically, these findings advocate for a nuanced approach to treatment selection, considering both

the surgical benefits and the individual patient's needs, ultimately guiding towards an optimal outcome.

CONCLUSIONS

1. Our study indicates a preference for Elastic Stable Intramedullary Nailing (ESIN) over plate fixation for pediatric femoral shaft fractures in children aged 5-10 years.
2. ESIN is associated with shorter operative times and faster commencement of weight-bearing, critical in pediatric recovery.
3. While ESIN is generally preferable, plate fixation may be better suited in certain clinical scenarios, emphasizing the importance of personalized treatment.
5. Based on our findings, ESIN is recommended for treating transverse diaphyseal femur fractures in the specified pediatric age group.
6. Recommends further studies, including randomized controlled trials, for a more comprehensive understanding of these treatments' long-term outcomes.

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