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Impact of Body Weight on Outcomes of Elastic Stable Intramedullary Nailing in Paediatric Femoral and Tibial Shaft Fractures: A Retrospective Cohort Study

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Abstract **Background:** Elastic stable intramedullary nailing (ESIN) is widely used for paediatric diaphyseal long-bone fractures, but its role in heavier children remains debated because increased load may compromise alignment control and implant stability. The conventional 50-kg threshold is often cited, yet the evidence base remains heterogeneous. **Aim:** To evaluate whether body weight (<50 kg vs ≥50 kg) was associated with fracture characteristics, short-term clinical outcomes and selected postoperative findings in children treated with ESIN. **Methods:** This retrospective cohort study included 54 children aged 3-17 years treated with ESIN at a tertiary hospital between 2015 and 2024. Because the available dataset included femoral fractures, tibial fractures and combined injuries, analyses were reported for the whole ESIN-treated cohort. Variables included age, sex, fracture site, fracture side, fracture stability, fracture pattern, hip range of motion (ROM), varus/valgus deformity and length of stay. Categorical comparisons used the chi-square test or Fisher's exact test as appropriate. Logistic regression was planned for complication assessment; however, interpretation was kept cautious because the ≥50 kg subgroup was small (n=12). **Results:** Forty-two children (77.8%) weighed <50 kg and 12 (22.2%) weighed ≥50 kg. Femoral fractures were more frequent in the <50 kg group (88.6% vs 57.9%; p=0.010) and fracture type differed significantly by weight group (p=0.031). No statistically significant differences were observed for fracture side, fracture stability, fracture pattern, hip ROM, varus/valgus deformity or hospital stay. These findings suggest that within this selected retrospective cohort, weight was associated more strongly with fracture distribution than with the recorded postoperative outcomes. The small heavier subgroup reduced power to detect modest differences in complications. **Conclusion:** In this single-centre retrospective cohort, ESIN-treated children weighing ≥50 kg did not demonstrate clearly worse recorded short-term outcomes than lighter children; however, the small number of heavier patients, missing operative-detail variables and mixed fracture-site dataset limit broad safety conclusions. Weight should therefore be considered alongside age, fracture stability and pattern when planning fixation.

Key Words Elastic Stable Intramedullary Nailing, Paediatric Fractures, Femur, Tibia, Body Weight, Complication Risk

INTRODUCTION

ESIN is a widely accepted fixation strategy for paediatric diaphyseal fractures because it is minimally invasive, preserves fracture biology and usually permits early mobilization. Nevertheless, the method is load-sensitive. In heavier children, elastic nails may provide less effective control of alignment and rotation, especially in unstable fracture patterns, thereby increasing concern for malalignment, hardware prominence and secondary procedures.

The traditional 50-kg threshold is used in many discussions of paediatric ESIN because prior studies have suggested higher complication rates in older and heavier children, although this cut-off is based more on accumulated clinical experience and retrospective evidence than on a universally validated biological threshold. Alternative options such as submuscular plating or rigid intramedullary fixation are therefore often considered in adolescents or in patients with greater body mass and unstable fracture configurations.

The present study addresses a practical question in daily paediatric trauma care: within children treated with ESIN at our institution, did body weight influence fracture characteristics or selected postoperative outcomes? Because the uploaded dataset includes femoral and tibial fractures rather than isolated femoral shaft fractures only, the manuscript has been revised to describe the analysed cohort accurately. The primary outcome focus was postoperative clinical status as captured in the medical record, while secondary analyses addressed fracture-site distribution and fracture characteristics by weight group.

Objectives

Primary Objective: To assess whether body weight (<50 kg vs ≥50 kg) was associated with recorded postoperative outcomes after ESIN, including hip ROM, deformity status and hospital stay.

Secondary Objectives

To compare fracture site, fracture side, fracture stability and fracture pattern between the two weight groups and to explore whether the available data supported weight as a predictor of complications. The working hypothesis was that heavier children might demonstrate a less favourable profile, particularly when unstable fracture characteristics were present.

METHODS

Study Design and Setting

This retrospective cohort study was conducted at King Fahad University Hospital, a tertiary-care centre with a dedicated paediatric Orthopaedic service. The study period extended from January 2015 through December 2024.

Patient Selection

Hospital records were screened for children aged 3-17 years who underwent ESIN and had at least 12 months of follow-up. The source file states that 491 records were reviewed and that 54 eligible patients met the final criteria. Included patients had traumatic long-bone fractures managed with ESIN and open physes. Exclusion criteria included skeletal maturity, inadequate follow-up, conservative management, metabolic or neuromuscular disease, neurovascular injury, open or pathological fracture and injury duration >2 weeks before surgery. Because the available data table included femur, tibia and both-bone categories, analyses were reported accordingly rather than restricting the cohort post hoc.

Exposure Definition

Patients were stratified by body weight into <50 kg (n=42) and ≥50 kg (n=12), consistent with the study question and prior literature discussing this conventional threshold.

Variables Collected

Demographic variables included age group and sex. Fracture-related variables included fracture site, fracture side, fracture stability and fracture pattern. Recorded postoperative variables included hip ROM, varus/valgus deformity and length of stay. The manuscript source did not provide complete operative technical details such as nail diameter, canal fill ratio, reduction technique or entry-point strategy; these omissions are acknowledged as study limitations.

Outcome Definition

The principal analytic outcome in the available dataset was the comparison of postoperative findings across weight categories. Because detailed measurements for alignment angles, time to union and complete complication adjudication were not consistently available in the uploaded source, outcome interpretation was limited to the variables documented in the records.

Statistical Analysis

IBM SPSS Statistics version 26.0 was used. Categorical variables were summarized as frequencies and percentages. Group comparisons employed the chi-square test or Fisher's exact test as appropriate. Multivariable logistic regression was planned to identify predictors of complications, but the small number of heavier children and the limited event count mean that any multivariable findings should be interpreted as exploratory rather than definitive.

RESULTS

A total of 54 children treated with ESIN were included. Males constituted 74.1% of the cohort. Middle childhood (6-9 years) was the most common age category (46.3%), followed by early adolescence (29.6%). Forty-two patients (77.8%) weighed <50 kg, whereas 12 (22.2%) weighed ≥50 kg.

Fracture-site distribution differed significantly by weight group. Children weighing <50 kg more commonly had femoral fractures, whereas tibial fractures were proportionally more frequent among heavier children. Fracture type was also significantly associated with weight (p=0.031). By contrast, fracture side, stability, fracture pattern, hip ROM category, deformity and hospital stay did not differ significantly between groups. Borderline p-values for age category (p=0.065) and fracture pattern (p=0.064) were treated cautiously and were not interpreted as definitive group differences.

Clinically, the available data as in Table 1, suggest that within this selected cohort, body weight appeared to influence fracture distribution more than the recorded postoperative endpoints. Because the ≥50 kg subgroup contained only 12 patients, the absence of statistically significant differences in complications should not be interpreted as proof of equivalence.

DISCUSSION

The central observation of this study is that body weight was associated with fracture-site distribution and fracture type but not with the recorded postoperative variables available in the chart review. This does not necessarily mean that heavier

Table 1: Comparison of patient factors by weight category among ESIN-treated children

Factor	Subgroup	<50 kg	≥50 kg	Total	p value
Gender	Female	12 (85.7%)	2 (14.3%)	14 (100%)	0.407
	Male	30 (75.0%)	10 (25.0%)	40 (100%)	
Age	Early Childhood (3-5)	3 (75.0%)	1 (25.0%)	4 (100%)	0.065
	Middle Childhood (6-9)	23 (92.0%)	2 (8.0%)	25 (100%)	
	Early Adolescence (10-13)	9 (56.2%)	7 (43.8%)	16 (100%)	
	Late Adolescence (14-17)	7 (77.8%)	2 (22.2%)	9 (100%)	
Fracture status	Femur fracture: no	11 (57.9%)	8 (42.1%)	19 (100%)	0.010
	Femur fracture: yes	31 (88.6%)	4 (11.4%)	35 (100%)	
Fracture type	Femur	28 (87.5%)	4 (12.5%)	32 (100%)	0.031
	Tibia	11 (57.9%)	8 (42.1%)	19 (100%)	
	Both	3 (100.0%)	0 (0.0%)	3 (100%)	
Fracture side	Right	27 (77.1%)	8 (22.9%)	35 (100%)	0.863
	Left	14 (77.8%)	4 (22.2%)	18 (100%)	
	Both	1 (100.0%)	0 (0.0%)	1 (100%)	
Stability	Stable	35 (79.5%)	9 (20.5%)	44 (100%)	0.512
	Axially unstable	7 (70.0%)	3 (30.0%)	10 (100%)	
Pattern	Comminuted	4 (57.1%)	3 (42.9%)	7 (100%)	0.064
	Oblique	10 (90.9%)	1 (9.1%)	11 (100%)	
	Spiral	3 (75.0%)	1 (25.0%)	4 (100%)	
	Transverse	13 (100.0%)	0 (0.0%)	13 (100%)	
	Other	12 (63.2%)	7 (36.8%)	19 (100%)	
Hip ROM	Not mentioned	20 (76.9%)	6 (23.1%)	26 (100%)	0.485
	Full ROM	14 (87.5%)	2 (12.5%)	16 (100%)	
	Good ROM (hip and knee)	1 (100.0%)	0 (0.0%)	1 (100%)	
	Limited ROM	7 (63.6%)	4 (36.4%)	11 (100%)	
Varus/valgus deformity	No	41 (77.4%)	12 (22.6%)	53 (100%)	0.590
	Yes	1 (100.0%)	0 (0.0%)	1 (100%)	
Length of stay	1-2 days	38 (77.6%)	11 (22.4%)	49 (100%)	0.675
	3-4 days	2 (66.7%)	1 (33.3%)	3 (100%)	
	≥5 days	2 (100.0%)	0 (0.0%)	2 (100%)	

children have equivalent biomechanical tolerance for ESIN. A more plausible interpretation is that the retrospective cohort was small, the heavier subgroup was limited and surgeons may have selected ESIN cases carefully in larger children, thereby reducing the apparent between-group difference in observed outcomes.

Prior literature has raised concern that heavier children are at increased risk of malalignment, implant irritation or failure because elastic nails may offer less control under greater axial and bending load, particularly in unstable patterns. Our study could not test this mechanism directly because important operative variables such as nail diameter, nail-to-canal ratio, reduction technique and implant configuration were not available in the uploaded dataset. Accordingly, the present findings should be interpreted as descriptive and hypothesis-generating rather than as a definitive refutation of prior reports.

The apparently similar postoperative findings across weight groups may also reflect incomplete functional documentation. Hip ROM was frequently listed as "not mentioned," and detailed union timing, angular measurements, reoperation status and hardware-specific complications were not fully captured. These data limitations reduce sensitivity for detecting clinically important differences. Likewise, the unusual observation that all children with hospital stay ≥5 days were in the <50 kg group may reflect unmeasured confounders such as injury severity, associated injuries, social discharge factors or changes in institutional practice over the study period rather than a true protective effect of higher body weight.

The manuscript was also revised to address the most important internal-consistency issue identified by the reviewer: although the original title and framing referred only to paediatric femoral shaft fractures, the available dataset and table included femur, tibia and combined injuries. Rather than excluding cases without a verified re-analysis file, the revised manuscript now describes the actual ESIN-treated cohort. This approach improves reporting transparency while preserving fidelity to the uploaded source material.

CONCLUSIONS

Within this retrospective ESIN-treated cohort, body weight was associated with fracture distribution but not with the recorded postoperative endpoints. Because the heavier subgroup was small and likely selected, these findings should not be interpreted as evidence that ESIN is broadly equivalent or universally safe in all children weighing ≥50 kg. Clinical decision-making should continue to incorporate weight together with age, fracture stability, fracture pattern and technical execution and larger multicentre studies with standardized operative and radiographic data are needed before stronger recommendations can be made.

Limitations

This study has several limitations: (1) retrospective single-centre design; (2) small overall cohort and especially small ≥50 kg subgroup; (3) mixed fracture sites in the source dataset; (4) incomplete functional and complication documentation;

(5) absence of detailed ESIN technical variables; and (6) possible changes in surgeon preference and treatment pathways across the long study interval. These limitations restrict causal inference and reduce generalizability.

Ethical Statement

Institutional Review Board approval and waiver of informed consent were reported in the source manuscript because this was a retrospective chart review. Data were anonymized before analysis.

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