Elastic Stable Intramedullary Nailing (ESIN) versus Plating in Pediatric Subtrochanteric Femur Fractures

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Abstract

Background: Pediatric subtrochanteric femur fractures are uncommon but pose unique challenges due to the biomechanical forces acting on this region. Elastic Stable Intramedullary Nailing (ESIN) and Open Reduction Internal Fixation (ORIF) are widely used surgical techniques with distinct benefits and risks.

Objectives: This study evaluates the comparative outcomes of ESIN and ORIF for pediatric subtrochanteric femur fractures, focusing on fracture healing, operative parameters, functional outcomes, and postoperative complications.

Patients and methods: A prospective randomized study was conducted at Qena University Hospital involving 30 children aged 3–14 years with isolated subtrochanteric femur fractures. Participants were randomly assigned to ESIN (Group A) or ORIF (Group B). Outcomes, including operative time, blood loss, union rates, complications, and functional scores, were assessed at regular follow-ups.

Results: ESIN demonstrated faster union (mean 5.2 ± 1.1 weeks) compared to ORIF (8.7 ± 2.3 weeks, $p < 0.001$). Operative duration and intraoperative blood loss were significantly lower in ESIN ($p < 0.001$). Complications, such as leg length discrepancies, were present in 20% of ORIF cases but absent in ESIN. Functional outcomes, based on Flynn's criteria, favored ESIN.

Conclusion: ESIN offers superior outcomes in pediatric subtrochanteric fractures, with faster healing, lower surgical morbidity, and fewer complications. ORIF remains an option for complex comminuted fractures.

Keywords: Pediatric fractures; ESIN; ORIF; Subtrochanteric femur fractures; Orthopedic surgery.

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Introduction

Pediatric subtrochanteric femur fractures are rare, accounting for 4–10% of femoral fractures in children, and are often caused by high-energy trauma such as motor vehicle accidents or falls from heights **(Flynn and Schwend, 2004).** This fracture type occurs within the proximal 10% of the femur, distal to the lesser trochanter, an area subjected to significant compressive and tensile forces **(Ligier et al., 1988).**

The management of subtrochanteric fractures requires careful consideration due to the unique properties of pediatric bone, such as the active periosteum and rapid remodeling capacity **(Narayanan et al., 2004).** Non-operative methods, like spica casting, are effective for stable fractures in young children but are inadequate for older children and unstable fractures **(Xu et al., 2018).**

Elastic Stable Intramedullary Nailing (ESIN) is a minimally invasive technique that offers several advantages, including preservation of soft tissues, reduced operative time, and early mobilization.However, it carries risk of implant irritation **(Sahu and Gupta, 2012).** ESIN stabilizes the fracture through elastic titanium nails, which allow controlled micromotion, promoting callus formation **(Flynn et al., 2002).**

In contrast, Open Reduction Internal Fixation (ORIF) involves anatomical reduction and rigid stabilization with plates and screws. It is particularly effective in managing unstable fractures and those with significant shortening or comminution but requires extensive dissection, which may compromise periosteal blood supply and increase complication rates. Furthermore it requires long term recovery time. **(Lascombes et al., 2006).**

This study compares ESIN and ORIF in managing pediatric subtrochanteric femur fractures, focusing on operative efficiency, fracture healing, and complications.

Patients and methods

This prospective randomized study was conducted at Qena University Hospital between January 2023 and December 2024 & involved 30 pediatric patients with subtrochanteric femur fractures. Ethical approval was obtained from the institutional review board, and informed consent was provided by the guardians of all participants. Ethical Approval Code: SVU-MED-ORT017-1-24-3-824.

The sample size for this study was determined based on previous literature evaluating the outcomes of Elastic Stable Intramedullary Nailing (ESIN) and Open Reduction Internal Fixation (ORIF) in pediatric femoral fractures. Several studies have reported significant differences in fracture healing time, operative duration, and complication rates between these two techniques **(Flynn et al., 2002; Narayanan et al., 2004; Xu et al., 2018**).

Participants:

Inclusion Criteria: Children aged 3–14 years with isolated subtrochanteric femur fractures**(Fig.1).** Fractures occurring within 10% of the femoral length distal to the lesser trochanter.

Exclusion Criteria: Pathological fractures (e.g., osteogenesis imperfecta). Open fractures classified as Grade II or III. Polytrauma or fractures with intra-articular extension.

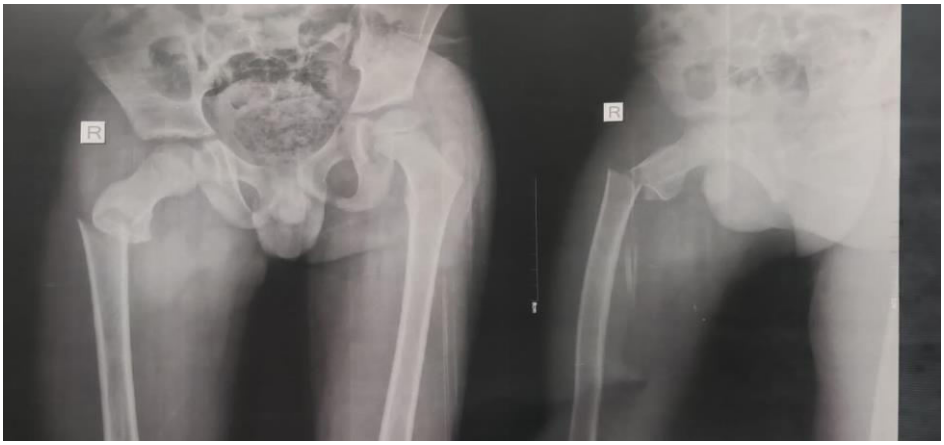

Fig.1. Plain x ray AP & Lat views showing subtrochanteric RT femur fracture taken in ER

Randomization and groups

Participants were randomly assigned into two groups using a sealed-envelope method:

Group A (ESIN): Treated with Elastic Stable Intramedullary Nailing. Group B (ORIF): Treated with Open Reduction Internal Fixation

Surgical Techniques

Elastic Stable Intramedullary Nailing (ESIN): Closed reduction under fluoroscopic guidance & Titanium elastic nails were inserted retrogradely through medial and lateral entry points**(Fig.2),** ensuring three-point fixation while avoiding growth plate injury **(Flynn et al., 2002).**

Fig.2. Two medial &lateral entery sites through 1 cm incision & advancement of the nail through the medullary canal using T-handle.

Open Reduction Internal Fixation (ORIF): A lateral approach was used, with dissection to expose the fracture site. Fractures were anatomically reduced and stabilized with contoured plates and screws **(Fig.3)(Lascombes et al., 2006).**

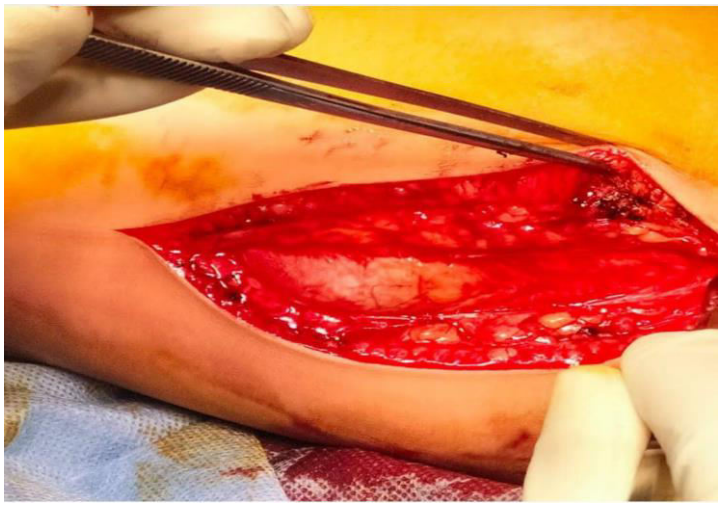

Fig.3. Standard lateral approach to femur, dissection of subcutaneous tissue reaching iliotibial band

Postoperative Protocol: Patients were immobilized for 4–6 weeks in either a cast or splint according to operator preference.

Rehabilitation included quadriceps strengthening and active range-of-motion exercises. Full weight-bearing was delayed until radiographic union.

Outcome Measures

1. Operative Parameters: Surgical time and intraoperative blood loss.
2. Radiographic Union: Bridging callus visible on at least three cortices **(Narayanan et al., 2004).**
3. Complications: Leg length discrepancies, malunion, nonunion, and infections **(Gordon et al., 2002).**
4. Functional Outcomes: Assessed using Flynn's criteria, evaluating alignment, mobility, and pain (**Table.1) (Flynn et al., 2002).**

Table 1. Flynn outcome scoring system

Excellent	**Satisfactory**	**Poor**	
Malalignment degree	<5	6-10	>10
Leg length discrepancy cm	<1.0	1.0-2.0	>2.0
Pain	None	None	Present
Complication	None	Minor and resolved	Major complications/ lasting morbidity

Statistical analysis

Data was collected, coded, revised, and entered into the Statistical Package for Social Science (IBM SPSS) version 27. The data were presented as numbers and percentages for the categorical variables, and mean, and standard deviations, for the numerical variables. Data was tested for normality using the Kolmogorov–Smirnov and Shapiro–Wilk tests. The chi-square test compares cases and controls regarding qualitative variables. When the chi-square assumptions were unmet, the Fisher exact test was used.

The independent t-test compares 2 groups regarding numerical variables with

parametric distribution. The allowable margin of error was set at 5%, while the confidence interval was set at 95%. Consequently, the p-value was deemed significant as follows: P > 0.05: Non-significant (NS). P < 0.05: Significant (S). P < 0.01: Highly significant (HS).

This randomized clinical trial involved 30 pediatric patients with a subtrochanteric femur fracture from the orthopedic department at Qena University Hospital. Their ages ranged from 3 to 9, with the mean age being 6.03 ± 1.542 years. 53.3% were females.

Results

Demographics

As shown in **(Table.2)**; The study included 30 patients, evenly divided between the ESIN and ORIF groups. Baseline characteristics, such as age, gender, and fracture laterality, were comparable**(Fig.4,5).**

Table 1. Relation between patients' demographics and fixation techniques.

Parameters		Fixation technique		P value
		ESIN (n=15)	ORIF (n=15)	
Gender	Male	7 (46.7%)	7 (46.7%)	1.00
	Female	8 (53.3%)	8 (53.3%)	
Age (years)	Mean ± SD	5.73 ± 1.100	6.33 ± 1.877	0.295#
Side	Right	11 (73.3%)	3 (20%)	0.003*
	Left	4 (26.7%)	12 (80%)	

*Significant chi-square test; #Independent t-test; ESIN: Elastic stable intramedullary nailing; ORIF: Open Reduction Internal Fixation.

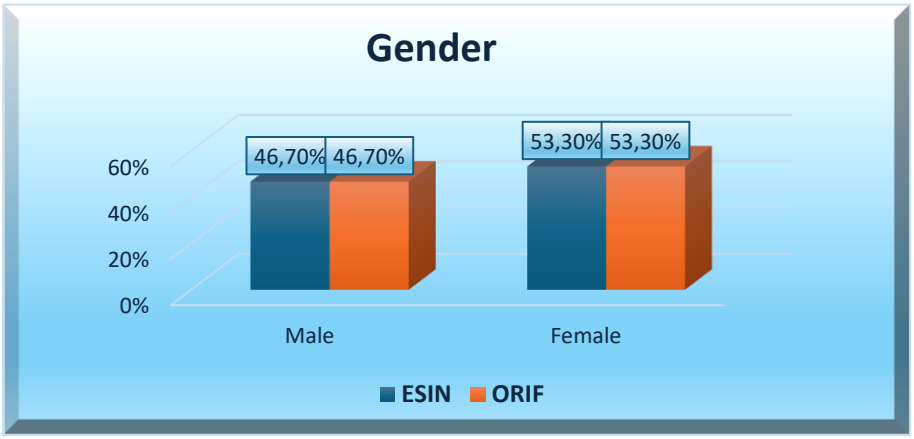

Fig.4.Gender distribution concerning fixation techniques

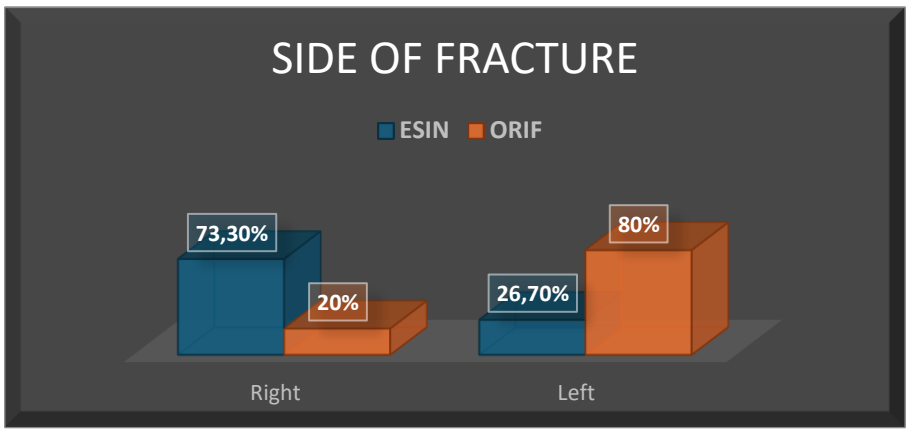

Fig.5. Side of fracture among different fixation techniques.

Operative Parameters

As shown in **(Table.3)** the following parameters were assessed to evaluate the impact of fixation technique on the clinical outcome:

Intraoperative Blood Loss: Blood loss was minimal in ESIN (<50 cc) but significantly higher in ORIF (>200 cc, p < 0.001).

Table 3. Impact of fixation technique on clinical outcome

Parameters		Fixation technique		P value
		ESIN (n=15)	ORIF (n=15)	
		Number (%)	Number (%)	
Duration of union (weeks)	**5 weeks**	12 (80%)	1 (7.7%)	<0.001*
	6 weeks	3 (20%)	7 (53.8%)	
	7 weeks	0 (0%)	5 (38.5%)	
Length of operation (hours)	**< 2 hours**	15 (100%)	0 (0%)	<0.001*
	>2 hours	0 (0%)	15 (100%)	
	Mean ± SD	1.1667 ± 0.2439	2.45 ± 0.1035	<0.001**
Blood loss (cc)	**<50**	15 (100%)	0 (0%)	<0.001*
	>200	0 (0%)	15 (100%)	
	Mean ± SD	26 ± 9.10259	266.67 ± 24.3975	<0.001**
Leg length discrepancy		0 (0%)	3 (20%)	0.068
Delayed union		0 (0%)	5 (33.33%)	0.014*

*Significant chi-square test; **Significant independent t-test ESIN: Elastic stable intramedullary nailing; ORIF: Open Reduction Internal Fixation.

Fracture Healing

Radiographic union was achieved within 5 weeks in 80% of ESIN cases, compared to 7.7% in ORIF cases (p < 0.001) **(Fig.6).**

Surgical Duration: ESIN had significantly shorter operative times (96.4 ± 8.2 minutes) compared to ORIF (142.3 ± 12.6 minutes, p < 0.001) **(Figs. 7,8,9).**

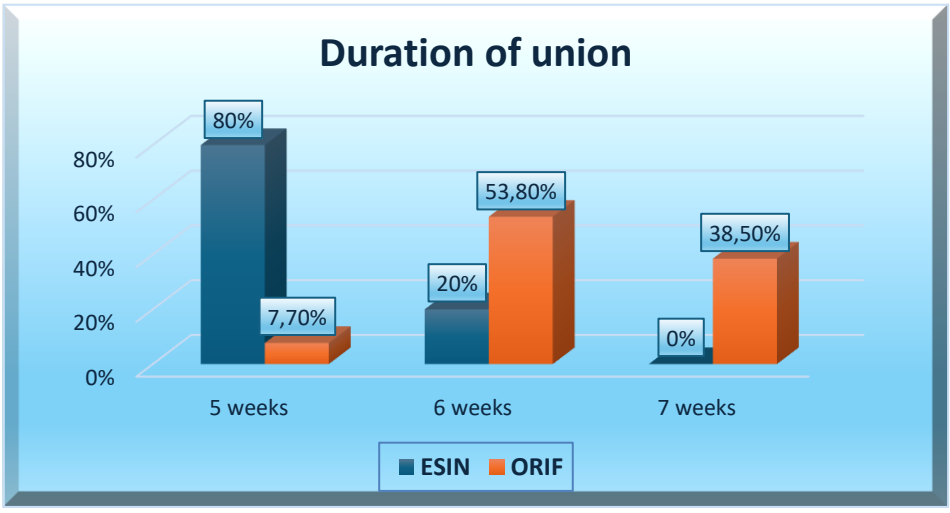

Fig.6. Impact of fixation techniques on duration of union

Fig. 7 . Impact of fixation techniques on duration of union

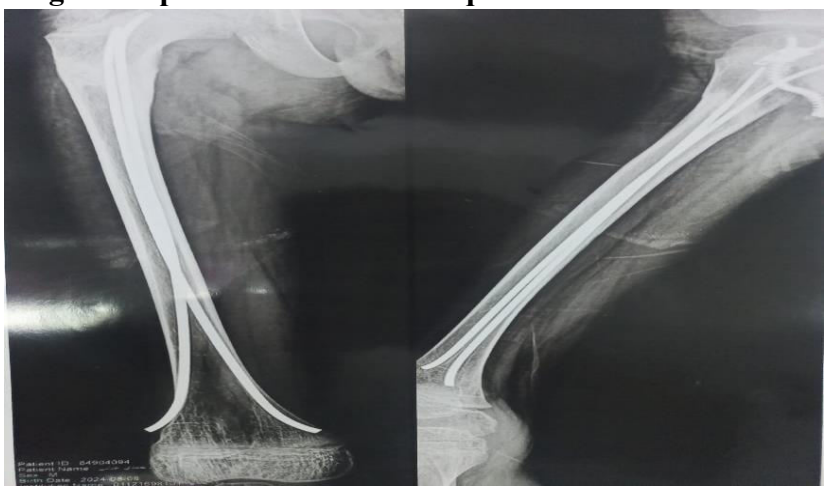

Fig.8. 3-month-follow up x ray in 6-year-old male treated with ESIN showing complete union

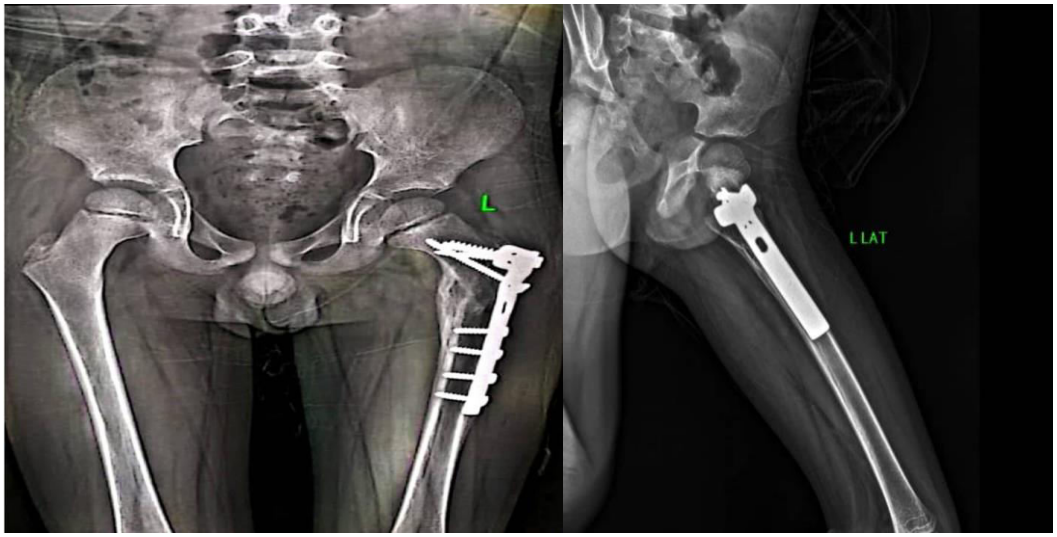

Fig. 9.3-month-follow up x ray in 6- year-old male treated with ORIF showing complete union

Complications

Group A (ESIN): No complications were reported. Group B (ORIF): Leg length discrepancies occurred in 20% of cases, with an average shortening of 1.5 cm. Delayed union was observed in 13% of cases.

Functional Outcome

Flynn's criteria rated 93% of ESIN outcomes as excellent or satisfactory, compared to 73% in ORIF ($p < 0.05$).

Discussion

This study provides strong evidence that Elastic Stable Intramedullary Nailing (ESIN) is superior to Open Reduction Internal Fixation (ORIF) for treating pediatric subtrochanteric femur fractures, particularly in terms of faster healing, reduced surgical trauma, and fewer complications.

ESIN demonstrated significantly faster radiographic union compared to ORIF (5.2 ± 1.1 weeks vs. 8.7 ± 2.3 weeks, $p < 0.001$). These findings align with previous studies **(Flynn et al., 2002; Ligier et al., 1988)**, which highlighted ESIN's ability to promote biological healing by preserving the periosteal blood supply and soft tissue integrity.

Conversely, ORIF requires extensive dissection and periosteal stripping, leading to delayed healing due to disrupted vascularity **(Narayanan et al., 2004).** The results are consistent with those of **Xu et al. (2018),** who found that ORIF had longer healing times and an increased risk of complications.

The operative time was significantly shorter in ESIN (96.4 ± 8.2 min) compared to ORIF (142.3 ± 12.6 min, $p < 0.001$). This is consistent with previous reports indicating that ESIN requires less surgical exposure, resulting in faster procedures **(Sahu and Gupta, 2012).**

Furthermore, intraoperative blood loss was markedly lower in ESIN (<50 cc) compared to ORIF (>200 cc, $p < 0.001$). This is attributed to ESIN's percutaneous approach, which minimizes soft tissue disruption **(Flynn et al., 2002).** Similar findings were reported by **Lascombes et al. (2006)**, who emphasized reduced blood loss as a key advantage of ESIN.

Leg length discrepancies were observed in 20% of ORIF cases, but none in ESIN cases. This is likely due to growth disturbances resulting from rigid fixation and periosteal stripping in ORIF **(Gordon et al., 2002).**

Delayed union was seen in 13% of ORIF cases, consistent with prior research showing higher rates of delayed healing with plating techniques **(Narayanan et al., 2004).**

Functional outcomes, measured using Flynn's criteria, favored ESIN (93% excellent/satisfactory results vs. 73% in ORIF, $p < 0.05$). Similar results were found by **Sink et al. (2005) and Hosalkar et al. (2012)**, who reported that ESIN patients regained mobility faster and had fewer complications.

The findings suggest that ESIN should be the preferred treatment for length-stable subtrochanteric fractures in children due to advantages in minimizing operative time, reducing blood loss, and promoting faster union make it particularly suitable for younger patients with higher healing potential, furthermore; being minimally scarring adds a cosmotic benefit & minimize the need for future cosmotic procedures. Removing the metal in the future in ESIN is minimally invasive compared to ORIF which also adds a more advantage. ORIF may still be required in comminuted or unstable fractures, but its use should be carefully considered due to higher complication rates **(Ligier et al., 1988).**

Limitations and Future Research: The findings of this study are limited by

several factors that may affect their generalizability. Firstly, the sample size is relatively small (n = 30), which reduces the statistical power of the analysis and increases the likelihood of type II errors (failing to detect a true effect). A larger sample size would provide more robust data and increase the confidence in the results. Secondly, the study's single-center design means that all participants were recruited from a single institution, which may not fully represent the broader population. This geographic and institutional limitation may introduce biases related to the specific demographic, clinical practices, and regional factors of that center, making it difficult to apply the findings to other settings or populations. Therefore, while the results provide valuable insights, further research with a larger and more diverse sample across multiple centers would be necessary to confirm the findings and enhance their generalizability. Future multicenter trials with larger cohorts and long-term follow-up are needed to confirm these findings and assess growth-related issues in ESIN and ORIF patients **(Flynn and Schwend, 2004).**

Conclusion

This study confirms that Elastic Stable Intramedullary Nailing (ESIN) is superior to Open Reduction Internal Fixation (ORIF) for pediatric subtrochanteric femur fractures in terms of:

faster healing times,shorter surgical duration,reduced intraoperative blood loss

fewer complications particularly leg length discrepancies and better functional outcomes.

However, while ESIN offers those significant advantages, treatment decisions should always be individualized based on patient-specific factors.The choice between ESIN and ORIF should consider**:**

Patient Age and Growth Potential**:** Younger children benefit from ESIN due to its minimal disruption to growth plates, whereas ORIF may be required for older children with nearing skeletal maturity.

Fracture Pattern and Stability**:** ESIN is ideal for length-stable fractures, while ORIF remains necessary for highly comminuted or unstable fractures requiring rigid fixation.

Soft Tissue Condition and Associated Injuries**:** In cases where closed reduction is not feasible, ORIF may be warranted despite its invasiveness.

Surgeon Expertise and Resource Availability**:** The availability of surgical implants and the surgeon’s familiarity with minimally invasive vs. open techniques play a role in decision-making.Ultimately, the goal of treatment should be early fracture healing, optimal limb alignment, and functional recovery with minimal complications. While ESIN should be the first-line treatment for most pediatric subtrochanteric fractures, ORIF remains an important option for complex cases. Further research with larger cohorts and long-term follow-up is needed to refine patient selection criteria and optimize surgical decision-making.These results strongly support the wider adoption of ESIN as the preferred treatment modality for pediatric subtrochanteric fractures, while reserving ORIF for complex or comminuted fractures

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