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## Flexible intramedullary nailing versus plate and screws fixation of 5-15 years old femoral fractures

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### Abstract

**Background:** Femoral fractures in children are a significant orthopedic challenge, often necessitating surgical intervention to ensure optimal healing and function.

**Objectives:** This study aims to compare the clinical outcomes and perioperative parameters of flexible intramedullary nailing (FIN) versus plate and screw fixation in pediatric femoral fractures.

**Methods:** A total of 63 children aged 5-15 years with femoral fractures were randomized into two groups: 32 treated with FIN and 31 with plate and screw fixation, assessing operative time, blood loss, and time to union. Results: The FIN group demonstrated shorter operative times (Mean 48.37 minutes) and less blood loss (Mean 40.62 cm<sup>3</sup>) compared to the plate and screw group (Mean 85.09 minutes and 105.32 cm<sup>3</sup>, respectively). Radiological union was faster in the FIN group (Mean 7.21 weeks) than the plate group (Mean 8.58 weeks).

**Conclusion:** FIN is superior to plate and screw fixation in treating pediatric femoral fractures, offering faster union and reduced operative times and blood loss, although weight-bearing times post-surgery were similar between the groups.

**Keywords:** Compared, loss, group

### Introduction

Femoral fractures in children, particularly those involving the shaft and supracondylar regions, are significant injuries that can result from high-energy trauma, such as falls or vehicular accidents, and in some cases, from low-energy incidents in children with pre-existing conditions like cerebral palsy (Loder *et al.*, 2023; Yeung *et al.*, 2016; Miyamoto *et al.*, 2021; Lu *et al.*, 2022) [19, 29, 25, 20]. The pathology of these fractures often involves disruption to the bone's integrity, which can lead to complications such as malunion or delayed healing if not properly managed (Haram *et al.*, 2022; Boyle *et al.*, 2017) [13, 7]. Surgical intervention, including the use of Kirschner wires, hip spica casts, flexible stainless-steel intramedullary nailing, and elastic stable intramedullary nailing combined with temporary external fixation, plays a crucial role in stabilizing the fracture, promoting proper bone healing, and restoring function (Rehm *et al.*, 2020; Persian *et al.*, 2018) [28, 27]. These treatments have shown satisfactory outcomes in terms of bone union and functional recovery in children aged 4–15 years (Jing *et al.*, 2023) [14]. However, the choice of surgical technique is influenced by the fracture's location, type, and the child's age and overall health.

Plates and screws fixation is a critical surgical intervention for treating femoral fractures in children, offering stability and promoting effective healing (Chen *et al.*, 2023; Cope *et al.*, 2023; Madhuri *et al.*, 2014; Factor *et al.*, 2023) [8, 9, 22, 10]. The locking compression plate (LCP) technique has emerged as the latest treatment method for the proximal femoral fractures. However, they seem to have more failure rates compared to the intramedullary nailing (Cope *et al.*, 2023; Becker *et al.*, 2012; Haider *et al.*, 2024) [9, 5, 12]. Minimally invasive plate osteosynthesis (MIPO) methods have been modified for pediatric femoral shaft fractures, which bring benefits such as smaller surgical trauma and faster recovery to children (Mikhael *et al.*, 2022) [24]. Besides this, apart from the application of biodegradable plates for noninvasive procedures, the option of using only biodegradable plates has been reviewed, and it has shown an excellent compatibility in pediatric fracture management in

avoiding a future surgical process for hardware removal. Nevertheless, the fixation technique should take into account the fracture, age of the child and specific anatomical consideration to minimize complications and achieve best result (Mifsut-Miedes *et al.*, 2022; Layher *et al.*, 2023; Furdock *et al.*, 2023) [21, 17, 11].

Flexible intramedullary nailing (FIN) that has the ability to move together with the femur growth is a common surgery used on hip fractures in children, with a better outcome for those aged from 5 to 11 years old (Antabak *et al.*, 2020; Khanna *et al.*, 2017) [2, 15]. This approach is favored because it is minimally invasive and it provides stable fixation allowing early mobilization and weight-bearing (Barnett *et al.* 2021, Lewis *et al.* 2019) [4, 18]. It is proven by the researches that FIM leads to faster recovery and less frequent hospitalization than in those patients who undergo conservative treatments and casts (Kanel *et al.* 1995) [16]. The technique involves a case of the insertion of shaped nails according to the femur curve that help in the maintenance of positioning which assists in faster bone healing (Khanna *et al.*, 2017) [15]. The method has some benefits such as the faster bone healing, but it is not without problems which may include a nail hole infection or implantation site irritation (Antabak *et al.*, 2020) [2]. Overall, FIN remains a cornerstone in pediatric orthopedic surgery for femoral shaft fractures due to its balance of efficacy and safety.

### Objectives

The purpose of this study was to evaluate the difference of clinical s outcomes and perioperative parameters between flexible intramedullary nailing (FIN) and plate and screw fixation for the treatment of femoral fractures in children less than 15 years. Actually, the goal of the research was to determine the following:

1. Operative time and blood loss during the surgical procedures.
2. Time to radiological union of the fracture.
3. Time to partial and full weight-bearing after the surgery.

### Methodology

#### Study Population

The study included 63 patients aged 5-15 years with femoral fractures, divided into two groups: 32 patients treated with FIN and 31 patients treated with plate and screw fixation. The demographic data and fracture characteristics of the two groups were comparable, as shown in Tables 1 and 2.

#### Ethical Approvals

The study protocol was reviewed and approved by the institutional review board (IRB) or ethics committee of the respective healthcare facility. Informed consent was obtained from the parents or legal guardians of all participants.

#### Inclusion Criteria

- Children aged 5-15 years
- Femoral shaft fractures (Diaphyseal and metaphyseal regions)
- Closed fractures
- Patients presenting within 7 days of injury

#### Exclusion Criteria

- Open fractures
- Pathological fractures (Associated with bone tumors or metabolic bone diseases)
- Previous surgeries or deformities involving the affected femur
- Patients with neuromuscular disorders or non-ambulatory status

#### Surgical Procedures

##### Flexible Intramedullary Nailing (FIN)

- Two nails of similar size (3.5-4 mm diameter) were inserted retrograde into the distal femoral metaphysis, one directed towards the femoral neck and the other towards the greater trochanter.
- Fracture reduction was optimized using a radiolucent fracture reduction tool.
- Fluoroscopy was used to confirm satisfactory reduction and nail placement.
- The nails were cut and seated securely in the distal femoral metaphysis.

##### Plate and Screw Fixation

- A long (10-14 holes) 4.5-mm narrow, low-contact dynamic compression plate (DCP) was used.
- The plate was inserted submuscularly beneath the vastus lateralis muscle.
- Kirschner wires were used to maintain fracture length and alignment.
- Self-tapping screws (6 cortices on either side of the fracture) were inserted percutaneously.

#### Intraoperative Measures

Operative time and blood loss during the surgical procedures were recorded for both groups.

#### Postoperative Follow-up

- Radiological assessment for fracture union was performed regularly.
- Time to radiological union, defined as the presence of bridging callus on at least three cortices on anteroposterior and lateral radiographs, was recorded.
- Time to partial and full weight-bearing was documented for both groups.

#### Statistical Analysis

The data were analyzed using appropriate statistical software (e.g., SPSS, R). Continuous variables (age, operative time, blood loss, time to union, weight-bearing timelines) were presented as mean  $\pm$  standard deviation (SD) and compared between the two groups using an independent t-test or Mann-Whitney U test, depending on the normality of data distribution. Categorical variables (Gender, fracture laterality, fracture pattern) were expressed as frequencies and percentages and compared using the chi-square test or Fisher's exact test, as appropriate.

#### Results

Table 1 shows the demographic data of the two patient groups. The mean age and gender distribution were comparable between the FIN and plate and screw fixation groups ( $p=0.49$  and  $p=0.79$ , respectively).

**Table 1:** Patients demographic data

	Flexible nail n (32)	Plate and screw n (31)	p value
Age mean+/-SD	9.37+/-2.37	9.38+/-2.41	0.49
Male gende n (%)	19(59.37%)	18(58%)	0.79

Table 2 demonstrates the similarity in fracture characteristics between the groups. The laterality of the fractures (Right vs. left) and the fracture patterns

(Transverse, oblique, or spiral) were evenly distributed, with no significant differences ( $p>0.05$  for all comparisons).

**Table 2:** Fracture characteristics

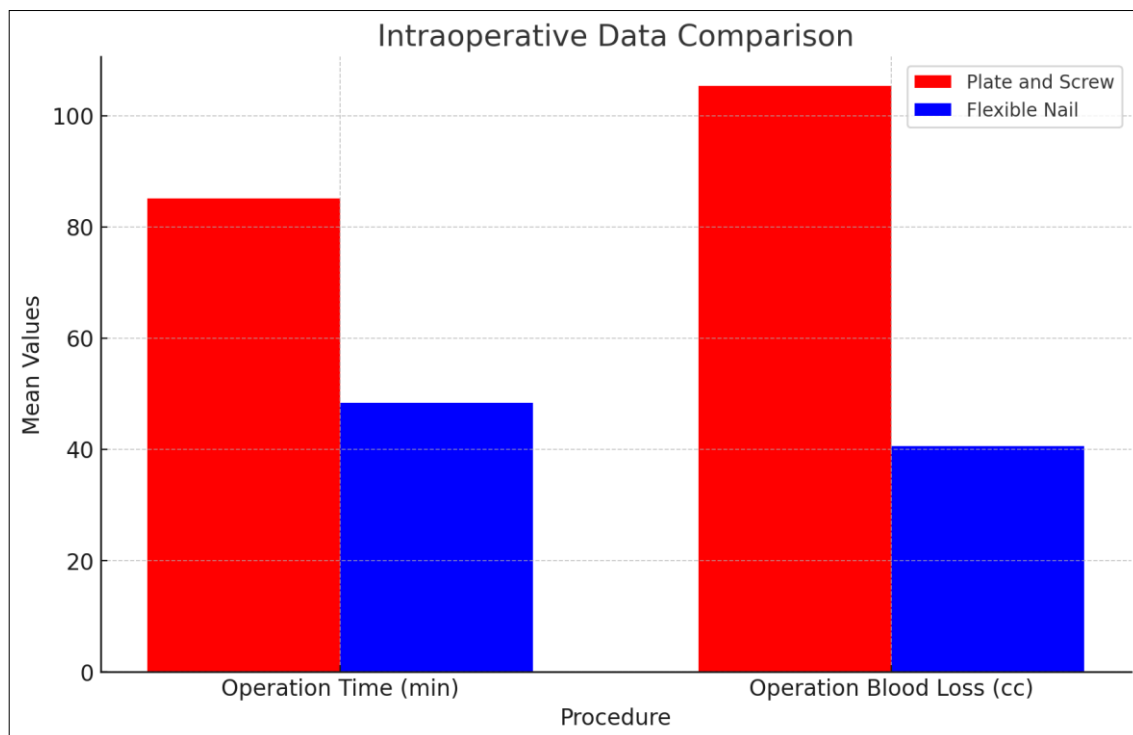
	Flexible nail n (32)	Plate and screw n (31)	p value
Right sided fracture n (%)	13(40%)	13(41.93%)	0.91
Transverse fracture n (%)	14(43.75%)	16(51.61)	0.53
Oblique fracture	11(34.37%)	10(32.25)	0.85
spiral fracture	7(21.87%)	5(16.12%)	0.56

Table 3 highlights the intraoperative parameters. The FIN group had significantly shorter operative times (mean  $48.37\pm 8.33$  minutes) compared to the plate and screw group (mean  $85.09\pm 15.61$  minutes,  $p<0.001$ ). Moreover, the FIN

technique was associated with lower intraoperative blood loss (mean  $40.62\pm 7.48$  cm<sup>3</sup>) than the plate and screw fixation (mean  $105.32\pm 54.63$  cm<sup>3</sup>,  $p<0.001$ ).

**Table 3:** Intraoperative data

	Flexible nail n (32)	Plate and screw n (31)	p value
Operation time in minutes(mean+/-SD)	48.37+/-8.33	85.09+/-15.61	<0.001
Operation blood loss in cubic cm (mean+/-SD)	40.62+/-7.48	105.32+/-54.63	<0.001

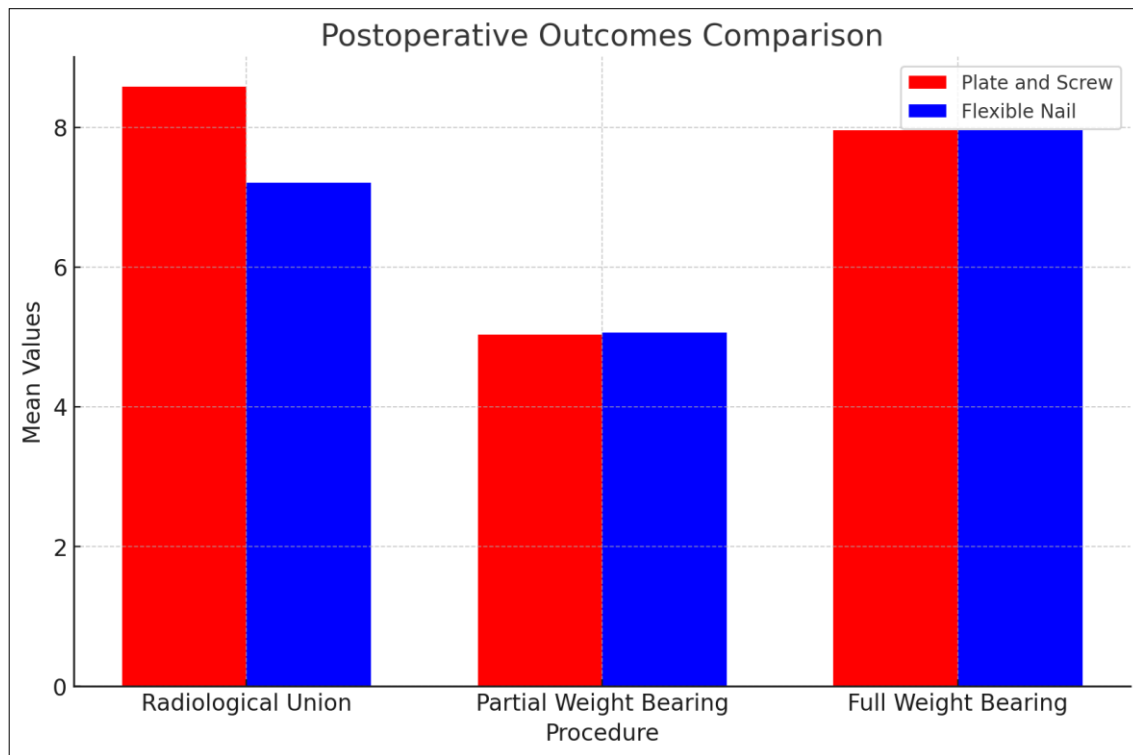
**Fig 1:** Operation time and operation blood loss in both study groups

In Table 4, the postoperative outcomes are presented. Patients treated with FIN achieved radiological union faster (mean  $7.21 \pm 1.09$  weeks) than those who underwent plate and screw fixation (mean  $8.58 \pm 1.11$  weeks,  $p<0.001$ ).

However, the time to partial weight-bearing ( $p=0.44$ ) and full weight-bearing ( $p=0.49$ ) was similar between the two groups.

**Table 4:** Post-operative outcomes

	Flexible nail n (32)	Plate and screw n (31)	p value
Time to radiological union in weeks (mean/-SD)	7.21+/-1.09	8.58+/-1.11	<0.001
Time to partial weight bearing in weeks (mean+/-SD)	5.06+/-0.84	5.03+/-0.83	0.44
Time to full weight bearing in weeks (mean+/-SD)	7.96+/-0.98	7.96+/-0.79	0.49



**Fig 2:** Time to radiological union, partial and full weight bearing in both study groups

## Discussion

This study compared flexible intramedullary nailing (FIN) and plate and screw fixation for femoral fractures in children aged 5-15 years. The primary aim was to evaluate perioperative parameters and postoperative outcomes, including operative time, blood loss, fracture union, and weight-bearing milestones. 63 patients underwent either FIN (n=32) or plate fixation (n=31). A significant finding of our study was the shorter operative times, lower blood loss, and faster return to radiological union for FIN patients, while their weight-bearing timelines were comparable to the conventional fixation patients.

The importance of FIN implantation in the treatment of pediatric femoral fracture was shown in this study, compared to the procedure of plating and screwing, FIN is more efficient and safer for the patient. In that case, the FIN technicians had a greatly shorter operative time of 48.37 minutes when contrasted with the screw/plate ones whose average was 85.09 minutes. Furthermore, the FIN technique had significantly less blood loss intraoperatively by 40.62 cm<sup>3</sup> in contrast to 105.32 cm<sup>3</sup> in the plate and screw group. This result has the statistical significance, which would be an indication that in these areas, FIN has an evident advantage.

Supportive of the previous research papers the present research report also concludes relatively more blood loss during the open procedure as compared to the FIN technique. Given the investigations by Al-doori *et al.*, 2024<sup>[1]</sup>, in such case, elastic stable intramedullary nailing resulted in not so long maxillofacial corrective surgeries, and the patients can walk earlier than when using plate fixation. Along with that, Mao *et al.* (2023)<sup>[23]</sup> also found signs of less intraoperative blood loss and shorter hospital stays with FIN. These studies point to the concept that FIN gives less discomfort and recover quickly, which is important in the field of pediatric patients. However, it's important to note that some studies have reported no significant differences in

certain outcomes. For example, Bajelidze *et al.*, 2020<sup>[3]</sup>, analyzed outcomes in pediatric femoral shaft fractures and found no significant difference in the time to start partial weight-bearing between the FIN and plate groups, although they did note shorter operation durations and hospital stays for the FIN group.

The advantages of FIN, particularly in terms of reduced operative time and blood loss, can be attributed to several factors: Minimally Invasive Approach where FIN typically requires smaller incisions than plate and screw fixation, which reduces tissue disruption and operative time, Simplified Surgical technique as the technique of inserting flexible nails is generally less complex and can be performed more quickly than the meticulous process of aligning and securing a plate with multiple screws and finally, Reduced Blood Loss where the less invasive nature of FIN, along with fewer and smaller incisions, naturally leads to less blood loss. This is critical in managing pediatric patients, where minimizing blood loss is a priority. The present study indicates that patients treated with flexible intramedullary nailing (FIN) for femoral fractures in children achieved radiological union significantly faster than those treated with plate and screw fixation, with mean times of 7.21 weeks and 8.58 weeks, respectively. Despite this faster union time, the duration until patients could engage in partial and full weight-bearing was similar between the two groups, with no statistically significant differences (p=0.44 and p=0.49, respectively). The findings of your present align with some aspects of previous research while contrasting in others. For instance, a study by Bajelidze *et al.*, 2020<sup>[3]</sup>, also found no significant difference in the time to start partial weight-bearing between groups treated with titanium elastic nails and those with plate fixation. However, they noted shorter operation durations and hospital stays for the FIN group, which is consistent with the general trend of FIN being less invasive. On the other hand, Mikhael *et al.*, 2022<sup>[24]</sup>, reported that minimally invasive plate osteosynthesis in

children led to satisfactory outcomes, though the study did not specifically compare weight-bearing times. In contrast, Rantam *et al.*, 2022 <sup>[26]</sup> found that patients treated with retrograde intramedullary nailing for distal femoral fractures had a slightly longer healing time compared to those with locking compression plates, which is opposite to your findings. This discrepancy could be due to differences in fracture types, patient age groups, or surgical techniques. The faster radiological union observed in the FIN group in your study could be attributed to several factors:

**Biomechanical Advantage:** FIN provides stable fixation while allowing for some degree of micromotion at the fracture site, which can enhance callus formation and speed up the healing process.

**Less Surgical Trauma:** FIN involves smaller incisions and less soft tissue dissection, which might reduce the physiological stress on the healing bone and promote quicker union.

The similar times to weight-bearing despite faster union with FIN might be explained by:

- 1. Clinical Protocols:** Postoperative rehabilitation protocols, which often are standardized across surgical techniques, might not have been adjusted to take advantage of the quicker healing times observed with FIN.
- 2. Caution in Weight-Bearing:** Physicians might prefer a conservative approach to weight-bearing to ensure full healing, regardless of radiological evidence of union, especially in pediatric patients where safeguarding long-term function is crucial.

## Conclusion

The study conclusively demonstrates that flexible intramedullary nailing is a more effective and efficient method for managing femoral fractures in children compared to plate and screw fixation. It significantly reduces operative time and blood loss while achieving faster bone healing. These advantages make FIN a preferable option in pediatric orthopedic surgery, although both methods show similar times to weight-bearing postoperatively. Further research could explore optimizing postoperative care to leverage the faster healing times associated with FIN.

**Conflict of Interest:** Not available

**Financial Support:** Not available

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