RETROGRADE FLEXIBLE INTRAMEDULLARY FIXATION OF PEDIATRIC FEMUR FRACTURES USING ALL-LATERAL ENTRY POINT TECHNIQUE

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ABSTRACT

Background: The most common orthopedic injury necessitating hospitalization in children is femoral fractures(1).The American Academy of Orthopedic Surgeons recommends that clinicians consider using flexible intramedullary nailing for treatment of children aged 5 to 11 years having diaphyseal femur fractures (level of Evidence: III ,Grade of Recommendation: C). Antegrade placement of "C"-shaped and "S"-shaped nails, retrograde placement of 2 "C"-shaped nails (CC) through medial and lateral approaches, and retrograde placement of "C"-shaped and "S"-shaped nails (CS) through a single lateral approach are all nail configurations for flexible intramedullary nailing (FIMN).(2)

Objectives: The aim of this study was to evaluate the clinical and radiological results of paired CS flexible nails placed in retrograde manner for the treatment of pediatric femoral shaft fractures

Patients and methods: This study included 20 child aged from 5 to 12 years old with diaphyseal fracture femur treated by flexible intramedullary nailing (FIMN) in Helwan University and Sheikh Zayed specialized hospitals. The results were assessed at the end of follow up clinically using Flynn's score and radiographically by plain radiographs.

Results: They were 6 females (30 %) and 14 males (70 %). Their ages ranged between 6 to 12 years with a mean of 7.67 ±2.34 years. The duration of anesthesia in this study was 45 minutes. In this study, postoperatively, 14% of patients had no pain (VAS = 0), 30% had mild pain.

Conclusion: CS retrograde fixation technique for flexible nails provide excellent clinical, radiological outcomes and a low complication rate for the treatment of pediatric femur fractures. The CS technique can be a fast operation, but proper technique is critical to minimize shortening and malunion of pediatric femoral fractures.

Key Words: flexible intramedullary fixation, pediatric diaphyseal femur fracture,

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INTRODUCTION

The most common orthopedic injury necessitating hospitalization in children is femoral fractures. In pediatrics, femoral shaft fractures occur for about 1.6 percent of all fractures (3).

High-energy trauma is the most common cause of femoral shaft fractures in children over the age of six, with motor vehicle incidents accounting for more than 90% of injuries in this age group.

Pediatric orthopedic surgeons have a tendency to fix older children's femur fractures intra-operative and treat younger children's femur fractures conservatively (3). Closed reduction and spica casting can be used to treat patients under the age of five, however teenagers with a closed proximal femoral physis should be treated with rigid intramedullary nailing(4).

Flexible intramedullary nailing for the repair of femoral shaft fractures in children and young adolescents has grown in popularity during the last 15 years.

Flexible nailing has a number of advantages over typical nonsurgical treatment options for juvenile femoral shaft fractures, including shorter hospital stays, quicker patient movement, and lessening the psychosocial effects of protracted immobilization(5). Furthermore, when compared to external fixation, this approach appears to offer distinct advantages over other surgical treatment alternatives because it does not appear to have the same refracture risk (6), requires less exposure than does plate fixation(7) and avoids the complications of femoral head osteonecrosis and premature greater trochanteric epiphysiodesis associated with rigid intramedullary devices(8).

The American Academy of Orthopedic Surgeons recommends that clinicians consider using flexible intramedullary nailing for treatment of children aged 5 to 11 years having diaphyseal femur fractures (level of Evidence: III ,Grade of Recommendation: C).

Antegrade placement of "C"-shaped and "S"-shaped nails, retrograde placement of 2 "C"-shaped nails (CC) through medial and lateral approaches, and retrograde placement of "C"-shaped and "S"-shaped nails (CS) through a single lateral

approach are all nail configurations for flexible intramedullary nailing (FIMN)[9].

PATIENTS AND METHODS

Patients:

20 child aged from 6 to 10 years old with diaphyseal fracture femur treated by flexible intramedullary nailing (FIMN) with "C"-shaped and "S"-shaped nails (CS) through a single lateral approach (AL).

Methods:

1. Diagnosis:

- fluoroscopy.
- History taking.
- Clinical examination.
- Routine preoperative laboratory investigations.
- X-ray of affected femur including hip and knee joints.

2. Treatment:

- General anesthesia.
- Prophylactic dose of IV antibiotic.
- **Position:** supine position on radiolucent table so we could see whole femur from hip to knee by the

Fig 1: position of patient and image intensifier

Sterilization: from above hip joint to the ankle. **Draping:** from hip joint to below knee joint.

Fig 2: sterilization and draping

Surgical technique: With guidance of the fluoroscopy, the physis was identified. One cm skin incision on the lateral aspect was made about 2cm above the physis.

Fig 3: identification of skin incision.

The skin and subcutaneous tissue were sharply incised, then blunt dissection through the muscles was done to reach the underlying bone.
Under fluoroscopic guidance, a 4.5 mm drill bit was used to drill the near cortex; first perpendicularly then gradually aiming superiorly reaching an angle of 45 degrees.
Awl was used to widen the opening as both nails were inserted through the same cortical opening.

Fig 4: Awl was used to widen the opening.

Flexible nails were then sized to the patient with the assistance of fluoroscopy, with a goal of 80% canal fill

Fig 5: Identification of size of nails used with help of image intensifier.

One of the rods was contoured to an “S” shape, whereas the other one was contoured to a “C” shape.

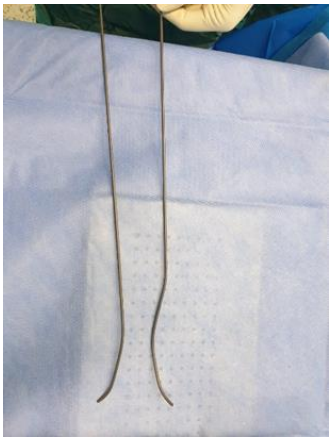


Fig 6: Contouring of nails.

The rods were then inserted through the cortical openings and passed to the fracture site.

Fig 7: insertion of first nail with help of image intensifier.

Fig 8: both nails were introduced to fracture site.

The fracture was reduced, the nails were passed across the fracture, and the implants were impacted into their final position. One nail was directed to the neck and the other to the greater trochanter.

Fig 9: nails were passed across the fracture.

The position of the nails was checked using the C-arm; they were then withdrawn 0.5 cm. The nails were pulled away from the bone and cut flush with its surface; leaving behind a small stump that was pushed in for 0.5 cm.

Fig 10: The nails were pulled away from the bone and cut flush with its surface; leaving behind a small stump that was pushed in for 0.5 cm.

Wound closure in layers.

Fig 11: wound closure in layers.

4. Postoperative management: Immediately postoperative all the patients had their femur X-rayed in AP and lateral views to check the position, size and length of the nails, the position of the fracture, any angulation or rotational deformity.

The patients were all admitted to the ward for 1-2 days where they received analgesic, anti-edematous medication and IV antibiotics

All patients were allowed full range of motion for the knee but strict non-weight bearing.

All patients were discharged within 48 hours where they received IV antibiotics; after obtaining postoperative X-rays and measuring their sound limb length and the fractured side with a tape measure.

They were followed up at 2 weeks post-operative for suture removal, then at 6 weeks post-operatively for follow up x-rays and assessment of union. At 3 months LLD, knee ROM, knee pain were assessed for each subject (Table 2.1). Full weight-bearing was allowed once union was achieved. At 6 months follow-up, Flynn's score was applied.

Statistical Methods:

Data were collected in a master sheet, coded, entered and analyzed using both SPSS version 22 medical statistics software and Microsoft Excel v. 2019.

The phase of analysis of data:

- Data were presented as Mean ± Standard deviation for quantitative variables & number and percentage for qualitative variables.
- Data were coded, entered and analyzed by computer package (version 10).
- Categorical data were compared using chi-square and calculated.
- The significance level was considered at P-value <0.05 for chi-square and when confidence interval of odds ratio (CI of OR) not including 1 in its range.

1) Descriptive statistics:

Arithmetic mean: as an average describing the central tendency of observations.

$$\text{Mean} \quad \left(\overline{X}\right) = \frac{\sum X}{n}$$

Where: ΣX = sum of individual data, n = number of individual data.

$$\sqrt{\frac{\sum\left(\overline{X} - X\right)^2}{n-1}}$$

Analytical analysis:

Chi-square $\chi 2$ test:

It is a test for significance for the difference between more than two proportions i.e., to assess whether the observed frequency (O) of an event departs significantly from that expected (E) on the basis of the null hypothesis. It can be calculated from the following equation:

$$\chi^2 = \frac{\sum(O-E)^2}{E}$$

Where: O = observed value.

E = expected value.

Expected value was calculated as follows:

$$E = \frac{(\text{row total})(\text{column total})}{\text{Grand total}}$$

Level of significance:

For all above mentioned tests done, the threshold of significance was fixed as 5% level student t-test (t) and the probability (P value):

- P value of > 0.05 indicates non-significant results.
- P value of < 0.05 indicates significant results.

RESULTS

This is a prospective cross-sectional, randomized study involving 20 patients with pediatric femur fractures treated by flexible intramedullary nailing (FIMN) using retrograde placement of "C"-shaped and "S"-shaped nails (CS) through a single lateral approach. They were 6 females (30 %) and 14 males (70 %). Their ages ranged between 6 to 10 years.

The body mass index (BMI) was about 17, the weight was about 31 kg and time till surgery was about 1 day. There was insignificant difference as regard BMI, weight, time till surgery and fracture type (P >0.05).

Fracture was simple diaphyseal in 65% (13) and comminuted diaphyseal in 35% (7) of patients.

There was significance regarding duration of anesthesia, duration of surgery, number of soaked surgical gauzes (blood loss) and number of radiation shots during surgery (P <0.05).

There was short anesthesia time and surgical duration in all lateral entry technique with statistically significant difference.

There was significant difference between both groups regarding infection. No infection reported in all lateral entry technique group while there was one case of infection in medial and lateral entry group.

There was insignificant difference regarding inflammation and weight bearing. No reported cases of neurological injury or refracture.

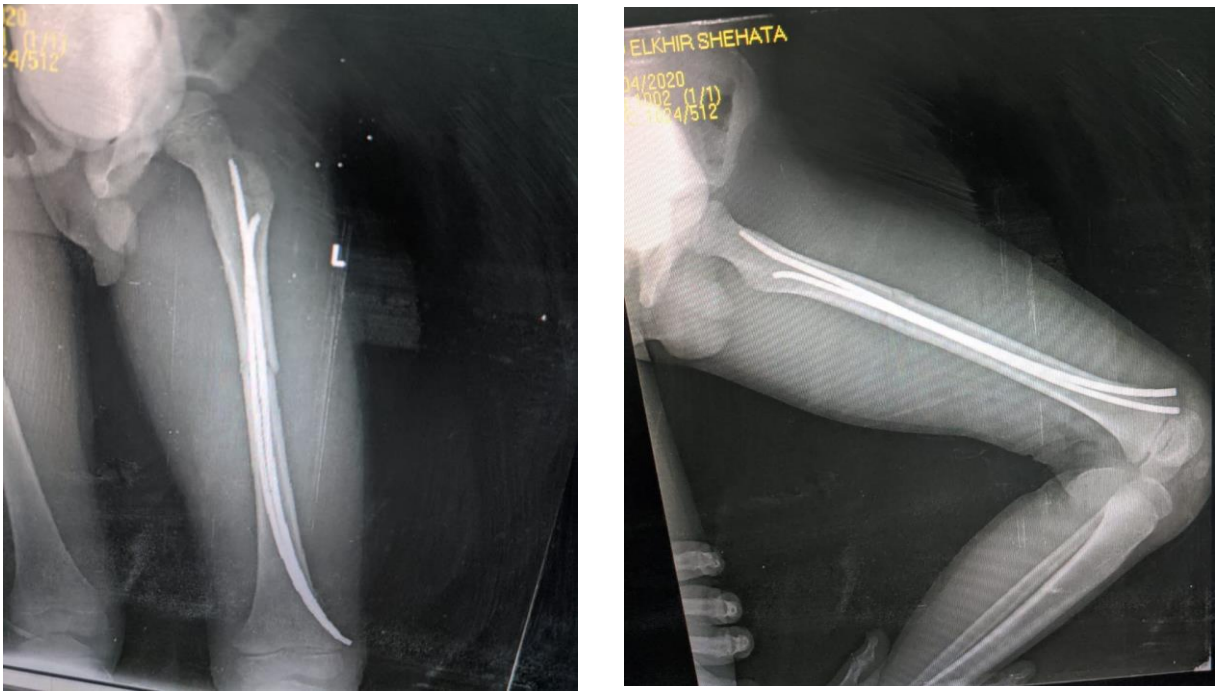
All lateral entry technique patients showed mild to no pain complaint with statistically significant difference (P < 0.05).

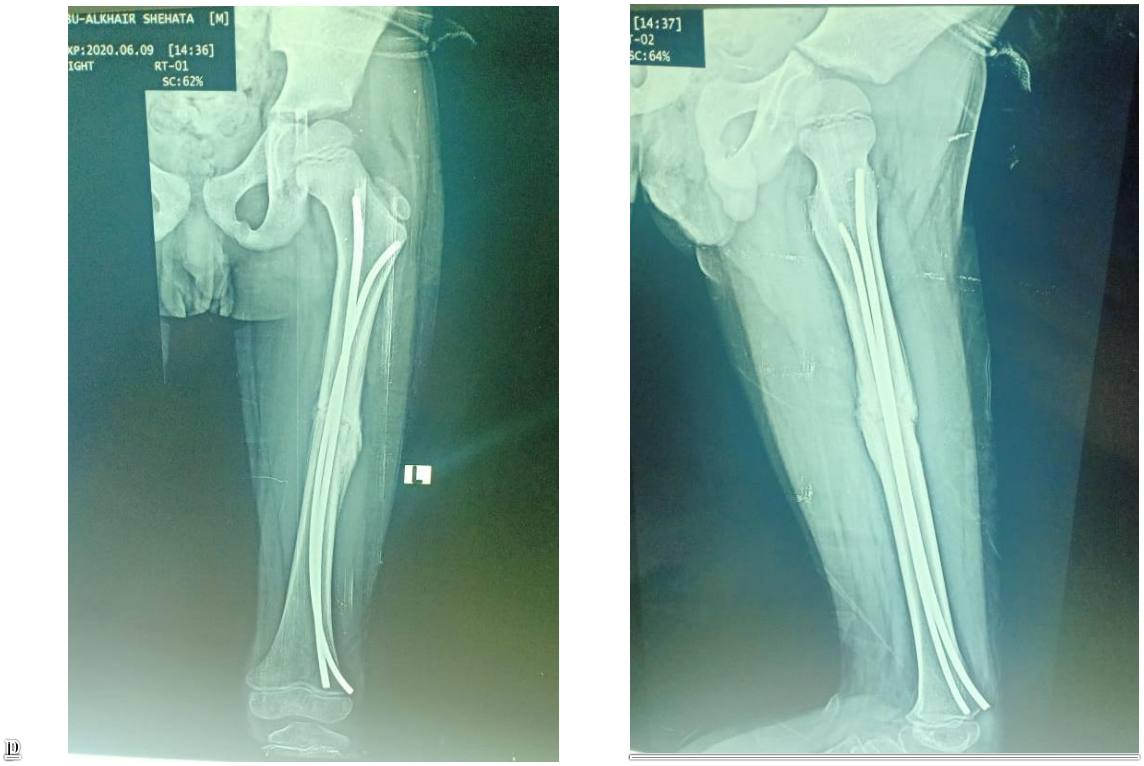
There was statistically significant difference regarding range of motion. Within the first week post-operative, 90% (18) of patients in all lateral entry technique patients gained 90 degree knee flexion,

All patients treated by all lateral entry technique showed excellent Flynn's score.

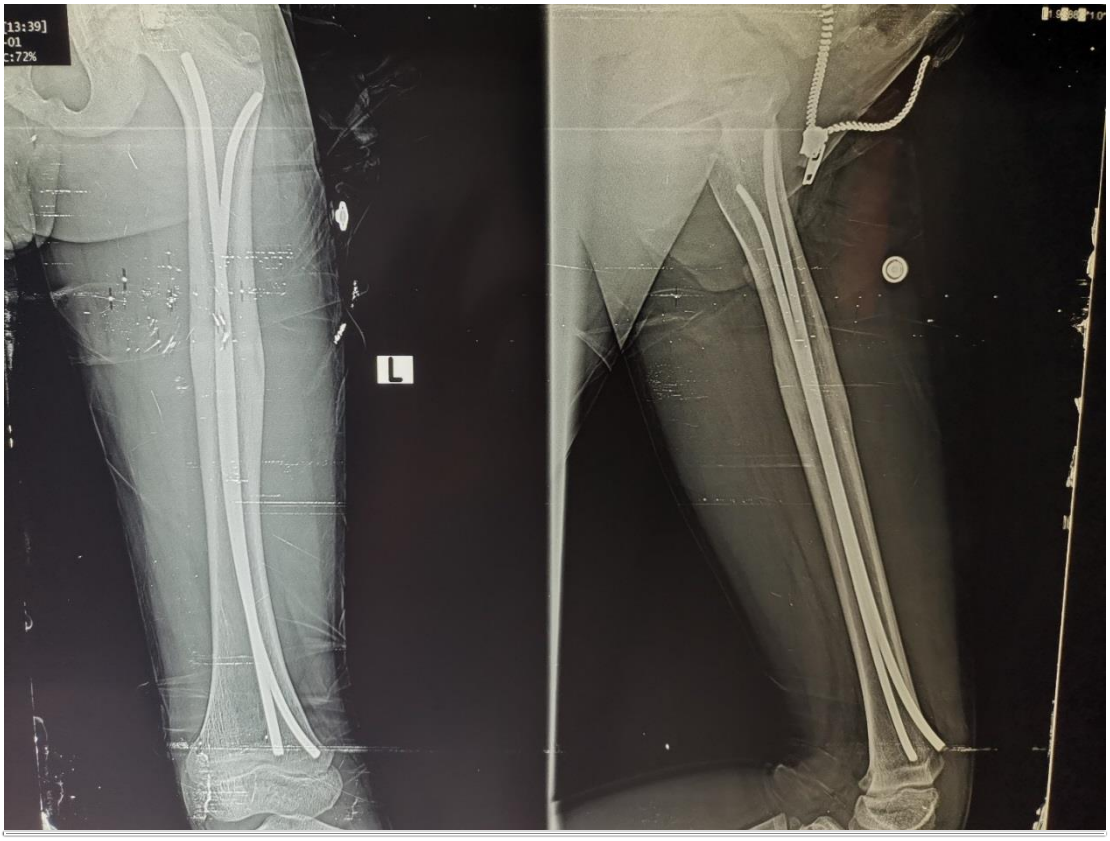
Patient 1

Preoperative x ray
immediate postoperative x ray (A) AP view, (B) lateral





Follow up x-ray (6 weeks postoperative) (A) AP view, (B) lateral view



Follow up x-ray (6 months postoperative) (A) AP view, (B) lateral view

DISCUSSION

Conservative treatment inevitably causes prolonged immobilization with negative effects on the child's social development, schooling, and family. As the demand for hospital beds grows, management methods that promote early mobilization and discharge gain traction (53).

Although there are a variety of treatment options for pediatric femoral shaft fractures, flexible intramedullary fixation is commonly regarded the gold standard of care for patients aged 6 to 11 (35). Over the past 2 decades, the indications and popularity of these implants have expanded as good clinical results and low rates of complications have been reported (55, 56).

Many authors cite the advantages of flexible intramedullary nailing over other techniques of fixation, including shorter length of hospitalization, decreased refracture risk, earlier mobilization, decreased risk of femoral head avascular necrosis, and decreased blood loss (56, 58).

There are two nail configuration possibilities when using an all-retrograde technique: medial and lateral (ML) distal entrance nails and all-lateral (AL) distal entry nails. Both techniques have been reported to have positive clinical outcomes (59, 60).

In this prospective cross-sectional study involving 20 patients with pediatric femur shaft fractures treated by flexible intramedullary nailing (FIMN) with "C"-shaped and "S"-shaped nails (CS) through a single lateral approach (AL). They were 6 females (30 %) and 14 males (70 %). Their ages ranged between 6 – 10 years with a mean of 7.67 ±2.34 years.

In comparison between this study and Cage et al. [59] Study, there was no difference in age and sex (74% vs. 82% males, P = 0.15). Both had an age range of 6–10 years with a mean of 8.6 years in the group.

Both studies showed statistically insignificant differences in average BMI. The average BMI in this study was 17.1 kg/m2 in the group and was 17.2 and 17.4 in Cage et al. (59)study. Also, it was similar in weight which was of average 31.4 kg and 30.9 kg in this study and it was 29.4 kg and 31.2 kg in Cage et al. (59) study.

There were insignificant differences between fracture patterns between both studies. Cage et al. (59)who found that fractures of the proximal third of the femur were present in 32 patients (36.4%) in AL group (P = 0.44). Fractures of the middle third were present in 52 patients (59.1%) in the AL group (P = 0.61). Fractures of the distal third of the femur were present in 4 patients (4.55%) in the AL group (P = 0.09).

The duration of anesthesia in this study was 45 minutes with a significant difference of p = 0.034. In Cage et al. (59) study ,there was a longer difference (30 min) between the two groups and a very high significance of P = 0.0001.

This study showed that CS had few complications.CS had only inflammation in 2 cases (10%).

Similarly, Cage et al.(59)recorded no infections in the AL group.

Cage et al. (59) found AL group had 3.0 mm (range, 0 to 21 degrees) of average shortening, 2.6 degrees (range, 0 to 17 degrees) of average absolute coronal angulation, and 2.7 degrees (range, 0 to 12 degrees) of average absolute sagittal angulation. There was no statistical difference in shortening, absolute sagittal angulation, or absolute coronal angulation ($p > 0.05$.

Limb length discrepancy was a frequent but clinically insignificant complication as most fractured limbs were within 1 cm in length of the contralateral normal limb (62). However, shortening of > 1 cm was observed in some patients having grade III or IV comminution in their study. Although the lesser degree of limb length discrepancy is fairly common, however, most published articles have reported infrequent occurrence of clinically significant discrepancy (23, 64).

It has been previously suggested that a CS retrograde technique in distal fracture patterns tends to produce a varus deformity (60). However, in reviewing all distal fractures in our patient population, we found no difference in coronal or sagittal angulation. Cage et al. (59) demonstrated that all femur fractures that healed with >10 degrees of valgus angulation (N = 3) were in the AL (CS) group. The presence of a valgus deformity >10 degrees did not correlate to fracture location. Although it is difficult to conclude only 3 patients, it is notable that all patients with clinically significant valgus had an AL nail construct.

Limitations:

It is important to note that our study has several limitations.

The very low number of patients was not enough to achieve accurate results, it was recommended that the next studied will be performed in large number of cases to achieve more reliable statistical results.

The study does not take into account the configuration of fracture during treatment decision-making because it may affect postoperative LLD and VAS scores.

While the all lateral entry technique was shown to be an average of 12 minutes faster than the medial and lateral entry technique , it is important to realize that the all lateral entry technique can be a more technically demanding operation, and one must be aware of its nuances to achieve similar results.

CONCLUSION

The all lateral retrograde fixation technique for flexible nails provide excellent clinical, radiological outcomes and a low complication rate for the treatment of pediatric femur fractures. The all lateral entry technique can be a fast operation, but proper technique is critical to minimize shortening and malunion of pediatric femoral fractures.

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