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Single Bone Fixation of The Radius Versus Ulna in Diaphyseal Forearm Fractures in Children

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Abstract

Introduction: Children and adolescents often sustain both-bone forearm fractures, which are common injuries.

Aim of the study: To investigate the efficacy of single-bone fixation of the radius versus the ulna in diaphyseal forearm fractures in children.

Subjects and Methods: There were 25 children with forearm both-bone fractures in a prospective cohort study. The ulnas of nine children (the ulnar cohort) and sixteen additional children (the radial cohort) were each treated with a single bone fixation utilizing an intramedullary flexible nail.

Results: Twenty-four children (nine (100%) from the ulnar cohort and fifteen (94%) from the radial cohort) had an excellent score, while a single one from the radial cohort lost about nine degrees of pronation and was given a good score. Only one case suffered from the delayed union of the ulna.

Conclusion: Both ulnar fixation and radial fixation had the same results in the treatment of both-bone fractures of the forearm of the children using single-bone fixation. They are reliable techniques with less operative time, excellent functional outcomes, a low rate of complications, and less radiation exposure.

Keywords: Forearm Fractures; Intramedullary Fixation; Paediatric Fractures; Both Bone Fractures; ESIN; Single Bone Fixation.

1. Introduction

Forearm fractures involving both bones occur often in children and teenagers. Numerous issues are in dispute in the field of juvenile orthopedics, including whether to operate, what constitutes an acceptable decrease, and when a child's innate capacity for remodeling becomes less effective [1].

Younger children, who still have more room for growth, have a greater capacity for remodeling than adolescents. According to other principles of pediatric fracture healing, fractures that are closer to more active muscles have a stronger tendency to remodel than those that are out of the plane of motion [2].

Children's forearm fractures can be treated with immobilization and closed reduction since they have a good ability to reconstruct and repair the angular deformity [3, 4]. Diaphysis fractures of the radius and ulna account for 3% of all pediatric fractures [5, 6]. The restoration of supination and pronation is the primary determinant of successful outcomes. The majority of earlier investigations on pediatric forearm fractures revealed favorable results during follow-up [7, 8].

On the other hand, information on outcomes measured after skeletal maturity is still lacking. In this study, we compare the effectiveness of single-bone fixation of the radius and ulna using elastic stable intramedullary nails ("ESIN") in the treatment of pediatric diaphyseal forearm fractures.

2. Subjects and methods

2.1.Subjects

There were 25 children with forearm both-bone fractures in a prospective cohort study. The ulnas of nine children (the ulnar cohort) and sixteen additional children (the radial cohort) were each treated with a single bone fixation utilizing an intramedullary flexible nail. At Fayoum University Hospital, the study was conducted from November 2021 to January 2023.

Inclusion criteria

- The age of the cases is between two and twelve years old.
- Children suffering from both-bone fractures.
- Fractures with a failed closed reduction trial in the ER.

Exclusion criteria

- Children above twelve and below two years old.
- Children had previous internal fixation.
- Children had pathological fractures.

2.2. Primary outcome

To determine whether ulnar fixation or radial fixation is a better method for the treatment both-bone fractures of the forearm in children.

2.3. Secondary outcomes

The duration of the radiological exposure, time to union, complications, and the duration of the operation.

2.4. Surgical procedure

The patient was positioned in the supine position after taking general anesthesia.

Under the direction of imaging, manual traction reduction was applied to the fractured side, and satisfactory reduction of the fracture was confirmed in both lateral and AP views. If the closed reduction fails, an open reduction is considered. The ulna was fixed antegrade, while the radius was fixed retrogradely.

The entry site for the ulna was 1 cm laterally to the dorsal ulnar rim and 3 cm from the tip of the olecranon, whereas the entry point for the radius was 1.5 cm proximal to the distal radial physis. While the ulnar incision began at the entry site and extended 2 cm proximally, the radial incision was made 2 cm commencing at the entry point confirmed by the image intensifier.

At the entry sites, a hole was made with an awl. Before the introduction of the nail, pre-contouring was carried out. The nail was pre-contoured to approximate the radial bow in the radius, and the tip was straightened in the ulna. The nail was put in using an oscillating motion. When a nail reaches the distal physeal of the ulna and the proximal physis of the radius, it is

stopped. The nail was gently pulled out by 1 cm, chopped outside the skin, and then gently reinserted using an impactor in its original location.

Elastic stable intramedullary nails (ESIN) were used to fixate the more dislocated bone intramedullary first, following the algorithm suggested by Myers et al., 1991 [9] (Figure 1).

Figure 1: Introduction of an ESIN through the radius with the maintenance of the reduction using a tip of a Hohmann retractor.

The stability of the opposite bone is then evaluated by passively moving the forearm through its complete range of supination and pronation. The fracture was classified as a stable single-bone fixation in patients who had no loss of reduction during the examination, and only one bone was fixed (Figure 2).

Figure 1: Image intensifier images showing single bone fixation of diaphysis both-bone forearm fracture with adequate reduction of the fracture.

2.5. Postoperative care

An above-the-shoulder cast or slab was put on right away following surgery to maintain reduction and provide analgesia. To evaluate the reduction and fixation of the fracture, plain X-rays were taken in the AP and lateral views. To allow the elbow to move actively, it must be properly immobilized for three weeks in an above-elbow cast or slab and then for another three weeks in a below-elbow cast or slab. The cast or salb was maintained in a position that allowed the best reduction under C-arm guidance. Plain x-rays were done every week for a month, then at 1.5 months, 2 months, and 3 months postoperatively. Removal of the elastic nail was done 6 to 9 months postoperatively.

3. Results

Twenty-five patients were involved in this article. The mean age among the study cohort was (8.5±2.6) years old, with 84% males versus 16% females. The patients were divided into two cohorts: the ulnar cohort (n = 9) and the radial cohort (n = 16). Seven of the children from the radial cohort and three of the children from the ulnar cohort had a fracture on the right side. Table 1 demonstrates the characteristics of the included participants.

Table 1: The characteristics of the included participants

Variables (n=25)	Ulnar n= 9	Radial n=16
Right side fracture	3	7
Left side fracture	6	9
Proximal fracture	1	3
Midshaft fracture	5	8
Distal fracture	3	5
Closed reduction	7	13

2.1. Outcomes

Duration of the radiological exposure and operation time

The mean operation duration of the ulnar cohort was (22.36±9.4) minutes while in the radial cohort was (23.35±9.6) minutes, and regarding the radiation exposure time, the mean in the ulnar cohort was (30±9.8) seconds while in the radial cohort was (30±9.8) seconds. There was a similarity between both cohorts with a $P>0.05$ regarding the time of the operation and the time of the radiological exposure.

Union time

The mean union time of the ulnar cohort was (6.04±0.84) weeks while in the radial cohort was (6.06±0.84) weeks. There

were no significant variations between both cohorts with a $P > 0.05$.

Functional score

In the ulnar cohort, 100% of the children showed excellent functional scores while in the radial cohort 94% had excellent functional scores. An only child in the radial cohort had a good functional score not excellent with loss of pronation about nine degrees. There were no significant variations between both cohorts with a $P > 0.05$.

Complications

Only one child in the ulnar cohort suffer from the delayed union and no other complications appeared in this cohort. The radial cohort did not show any complications. Table 2 demonstrates the details of the analysis of the outcomes.

Table 2: Analysis of the study outcomes.

Variables (n=25)	Ulnar n= 9	Radial n=16
Operative time (min)	22.36±9.4	23.35±9.6
Duration of radiological exposure (sec)	30±9.8	30±9.8
Time of union	6.04±0.84	6.06±0.84
good functional score	0	1
excellent functional score	9	15
Complications (n, %)		
present	1	1
absent	8	15

2.2. Case presentation

Case 1

A seven-year-old male presented with pain over his right forearm after falling to the ground. On examination, he had tenderness over the proximal forearm, and neurovascular examination showed intact pulsation and neurological function. The patient had a closed midshaft fracture of the right radius and ulna. The patient was managed with closed reduction under c-arm guidance, and fixation of the more displaced bone "radius" was done using a flexible intramedullary nail according to the algorithm proposed by Myers et al., 1991 [9]. Then the above elbow cast was done. The operative time was 32 minutes, and he was discharged the next day after the operation. Pre- and postoperative x-rays were done. The outcome grading score 3 months postoperatively was excellent (**Figure 3**).

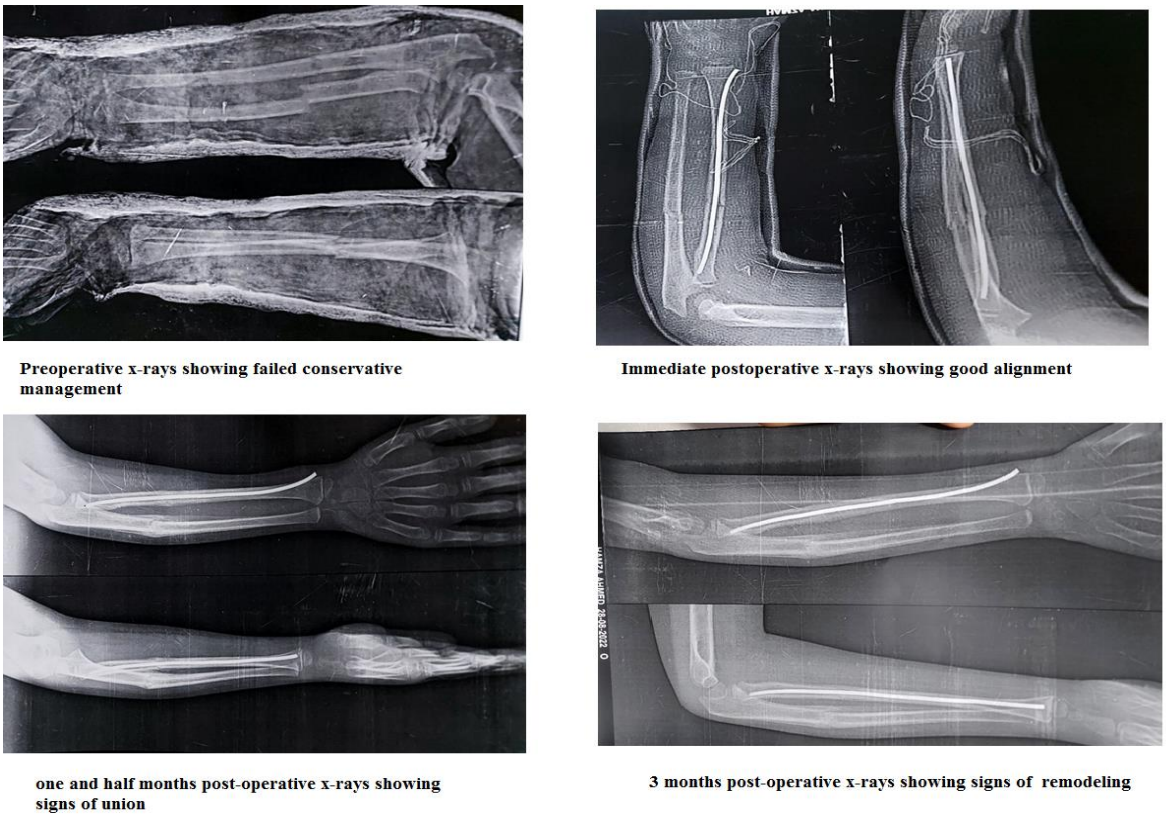

Figure 2: Radiological assessment of Case 1

Case 2

A twelve-year-old male presented with pain over his left forearm after falling to the ground. On examination, he had tenderness over the proximal forearm, and a neurovascular examination showed intact pulsation and neurological function. The patient had a closed midshaft fracture of the radius and a proximal shaft fracture of the ulna. The patient was managed with closed reduction under c-arm guidance, and fixation of the more displaced bone "radius" was done using a flexible intramedullary nail according to the algorithm proposed by Myers et al., 1991 [9]. Then the above elbow cast was done. The operative time was 40 minutes, and he was discharged the next day after the operation. Pre- and postoperative x-rays were done. The outcome grading score 3 months postoperatively was excellent (Figure 4).

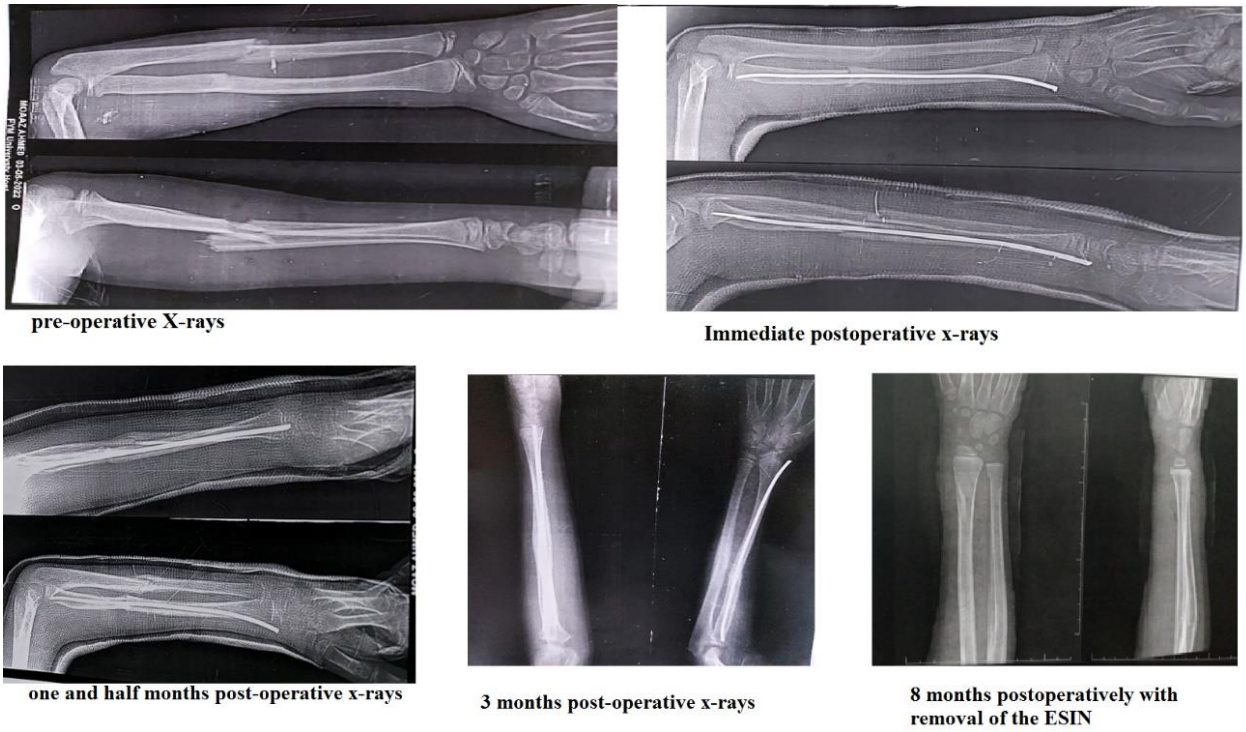

Figure 3: Radiological assessment of case 2.

4. Discussion

Forearm fractures in both directions are rather common. After pediatric supracondylar humeral fractures and distal radial fractures, they take third place. They account for roughly 13% of all paediatric fractures [10]. A minimally invasive treatment option for treating pediatric forearm fractures that fail closed reduction and casting is elastic intramedullary nailing. It has been demonstrated to be an effective way to achieve anatomic union with excellent function of the injured upper extremity in the majority of patients with very few postoperative problems [11, 12].

In our study, we found that there were no significant variations between the ulnar fixation and the radial fixation for the treatment of both-bone fractures of the forearm in the children regarding the complications, functional outcomes, time to union, time of the operation, and the duration of radiological exposure. In addition, we found that single-bone fixation for both-bone fractures of the forearm in children can cause excellent functional outcomes and a low incidence of complications.

A randomized clinical experiment was conducted by Colaris et al., 2013 [13] to evaluate the effectiveness of single-bone intramedullary fixation for children with unstable both-bone diaphyseal forearm fractures. They involved twenty-four cases with ages less than sixteen. Unlike our results, they found that single bone fixation

was less effective than double bone fixation and associated with a high incidence of re-displacement. In 2022, Khaled et al. conducted a clinical trial that involved a case [14]. They concluded that, in comparison to both-bone fixation, single-bone ulna open reduction and plate fixation and casting are safe and take less time to do. However, despite being clinically satisfactory, single-bone ORIF had a greater incidence of radius re-angulation. Both groups had forearm range of motion, union rates, and excellent functional results with no problems or refractures. There is a need for a lengthy study.

A retrospective study was performed by Du et al., 2016 to determine the most effective technique of fixation in the treatment of both-bone fractures in children [15]. They looked at 49 cases and discovered that ESIN repair is not always necessary for kids who have both-bone forearm fractures. Single-bone intramedullary treatment of the radius in younger children with both-bone forearm fractures delivers exceptional results and is a suitable and effective option. An intramedullary nail is advised in the radius and ulna of older children (age 10 years) to improve fracture stability, shorten the time spent in a cast, and reduce joint stiffness. By following these recommendations, kids with both-bone diaphyseal forearm fractures may benefit from successful bony healing and unhampered forearm function.

Houshian et al., (2005) conducted a study that aimed to investigate the efficacy of single bone fixation with ESIN in 20 cases [16]. They demonstrated that both bone forearm fractures in children between the ages of 6 and 14 frequently react favorably to single-bone fixation with flexible intramedullary nails, which was consistent with our findings. Kirkos et al., 2000 found the same results we found [17]. 50 children with unstable diaphyseal forearm fractures involving the radius and ulna who received open reduction and internal fixation of the radius only after closed reduction failed were retrospectively studied. The children ranged in age from 5 to 14; the mean age was 11. Since the radius's function is more complex than that of the other two forearm bones, stabilizing it is the aim of this treatment. The ulnar fracture exhibited better alignment following fixation of the radius and anatomical reduction. At a mean follow-up of 4 years (range 1 to 10 years), all children in this series had outstanding functional and anatomical results.

Limitations

Small sample sizes and the noncompliance of some patients during the follow-up period were the main limitations of our study.

Conclusion

Both ulnar fixation and radial fixation had the same results in the treatment of children who had both-bone fractures of the forearm using single-bone fixation. They are reliable techniques with less operative time, excellent functional outcomes, a low rate of complications, and less radiation exposure.

Ethical approval and consent to participate: no ethical approval is required.

Conflicts of Interest: All authors declare no conflict of interest.

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