



International Journal of Orthopaedics Sciences

E-ISSN: 2395-1958
P-ISSN: 2706-6630
IJOS 2024; 10(3): 81-84
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www.orthopaper.com
Received: 03-05-2024
Accepted: 04-06-2024

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Hybrid fixation for adolescent both-bones diaphyseal forearm fractures: Preliminary results of a prospective cohort study

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DOI: <https://doi.org/10.22271/ortho.2024.v10.i3b.3579>

Abstract

Introduction: Both-bone forearm fractures account for 3.4% of all pediatric fractures and 26% of all pediatric upper extremity fractures. Although non-operative management remains a feasible treatment option for children older than 10 years, they have a higher incidence for malunion due to their limited bone remodelling potential. Therefore, surgical intervention could be advocated for this age group, however the optimal method of surgical fixation in this age group remains controversial.

Methods: A single-center, prospective cohort study was conducted at an academic Level 1 Trauma Center from February 2016 to February 2019. A total of 50 patients (age 10-16 years) with both-bones forearm fracture were enrolled. Patients were assessed radiographically for union as well as clinically using the "Outcome Grading System" developed by Martus et al. for functional assessment of surgical management of pediatric forearm fractures using forearm rotation range of motion & complications rate.

Results: At final follow up for each patient (24 months) Union was achieved in all cases. Delayed union occurred in 4 patients (2 radii & 2 ulnae) with no case of combined radius & ulnar delayed union. At final follow up, the mean supination range was $81.27^{\circ} \pm 4.1^{\circ}$, while the mean pronation range was $68.17^{\circ} \pm 3.03^{\circ}$. The "Outcome Grading System" results were: 38 cases (76%) scored excellent, 10 cases (20%) scored good & 2 cases (4%) scored fair.

Conclusion: Hybrid fixation method in adolescent both-bones forearm fracture could be a viable option in managing these injuries & may reduce the problem of ulnar non-union encountered when using elastic stable intramedullary nail (ESIN) in that age group.

Keywords: Hybrid fixation, adolescent, both-bones diaphyseal forearm fractures, preliminary results and prospective cohort study

Introduction

Both bone forearm fractures are common in children and rare in adults. The main surgical treatment is open reduction and internal fixation (ORIF) with plate, while the hybrid fixation of elastic-stable intramedullary nailing (ESIN) and the plate has been rarely reported before [1]. Although non-operative management remains a feasible treatment option for children older than 10 years, they have a higher incidence for malunion due to their limited bone remodeling potential. Therefore, surgical intervention could be advocated for this age group,

Long bone fracture of forearm is common skeletal injury. The most common causes of such injuries include road traffic accident, fall or direct trauma, amongst the various types of forearm fractures, both-bone diaphyseal forearm fractures in adults are frequently met by the orthopedic doctors. There are various methods available for fixation of both bone diaphyseal fractures like both bone plate fixation, both bone intramedullary nailing and hybrid method with nailing in one of the bones and plating in other [2].

Both-bone forearm fractures account for 3.4% of all pediatric fractures and 26% of all pediatric upper extremity fractures. Although non-operative management remains a feasible treatment option for children older than 10 years, they have a higher incidence for malunion due to their limited bone remodeling potential. Therefore, surgical intervention could be advocated for this age group

This study is to evaluate hybrid fixation (plating of ulna & elastic nail for radius) of adolescent both-bone forearm fractures [3].

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Aims and objectives: The aim of this study is to evaluate hybrid fixation of adolescent both-bone forearm fractures in a large single-institution cohort of patients.

1. To estimate the union time & rate for the ulna fracture using the technique i.e., open reduction and internal fixation with plate and screws and closed reduction and internal fixation with elastic nail for radius
2. To estimate operative time, forearm supination-pronation range of motion & complications such as infection, malunion, non-union, injury to neurovascular structures

Materials & Methods

Study design: A prospective study

Duration of the study: 3 years February 2016 to February 2019

Source of Data: Patients admitted in Shridevi institute of medical science and research hospital

Inclusion criteria: Patients 10-16 years of age with simple, closed, diaphyseal both-bones forearm fracture

Exclusion criteria: those with open or pathologic or Monteggia or Galeazzi or bilateral fractures or those with compartment syndrome were excluded and those with fractures older than 14 days were also excluded

Sampling method: Convenience sampling

Sample size: 50 (A total of 50 patients (age 10-16 years) with both-bones forearm fracture will be enrolled in the study period)

The Sample size estimation will be done using the following formula:

$$(Z \alpha/2 + Z 1-\beta) / d \times 2 = n$$

Where n – is the sample size

$Z \alpha/2 = 1.96$ [For an alpha level of 5%, $\alpha=0.05$]

$Z 1-\beta = 0.84$ [For power of the study at 80%, $1-\beta=0.80$]

d – is effect size or Cohen's d [d=0.40, i.e. anticipating 40% of the patients will present with excellent improvement in the Outcome Grading System during the postoperative period] from previous literature from Ahmed S. Elhalawany *et al.*, 2019.

$n = 49.00$, which will be rounded off to 50

The total sample size for the present study will be 50.

Methodology (Describe your complete project stepwise)

It is a Retrospective study.

The study will be conducted at an academic Level 1 Trauma Center from February 2016 to February 2019.

A total of 50 patients (Age 10-16 years) with both-bones forearm fracture were enrolled follow up for each patient was done after (24 months).

Patients 10-16 years of age who presented to their service and suffered simple, closed, diaphyseal both-bones forearm fracture those with open or pathologic or Monteggia or Galeazzi or bilateral fractures or those with compartment syndrome will be excluded and Those with fractures older than 14 days are also excluded

The radius was fixed using one intramedullary nailing and ulna was fixed using a 3.5 mm dynamic compression plate

All patients will be systematically examined at the outpatient clinic after 2, 6 weeks, 3, 6 months and 2 years.

Clinical data (Forearm supination-pronation range) will be

obtained during follow up visits.

Radiographic data (Antero-posterior & lateral radiographs of the forearm to assess bony union) is obtained until either union was achieved or a diagnosis of non-union was established.

The "Outcome Grading System" developed by Martus *et al.* [8], was used for functional assessment

Table 1: Outcome grading system

Outcome grade	Range of motion	Complication graded
Excellent	Full	Grade 1 or none
Good	Loss of <100° pronation and/or supination	Grade 2 or less
Fair	Loss of 10-30° pronation and/or supination	Grade 3 or less
Poor	Loss of > 30° pronation and/or supination	Up to grade 5

Statistical Analysis Plan

Statistical Package for Social Sciences [SPSS] for Windows Version 22.0 Released 2013.

Armonk, NY: IBM Corp., will be used to perform statistical analyses.

Descriptive Statistics

Descriptive analysis of all the explanatory and outcome parameters will be done using mean and standard deviation for quantitative variables, frequency and proportions for categorical variables.

Inferential Statistics

Repeated Measures of ANOVA Test followed by Bonferroni's post hoc test / Friedman's test followed by Wilcoxon signed rank post hoc test will be used to compare the mean Supination and Pronation range of motion values, mean Outcome Grading System scores between different follow-up time intervals.

Cochran's Q Guide followed by McNemar's post hoc test will be used to compare the incidence of post-op complications between different follow-up time intervals.

The level of significance will be set at $p < 0.05$.

And any other relevant test, if found appropriate during the time of data analysis will be dealt accordingly.

Results

The study included 44 males (90%) and 6 females (10%), the mean age at time of enrolment was 11.83 ± 1.72 years

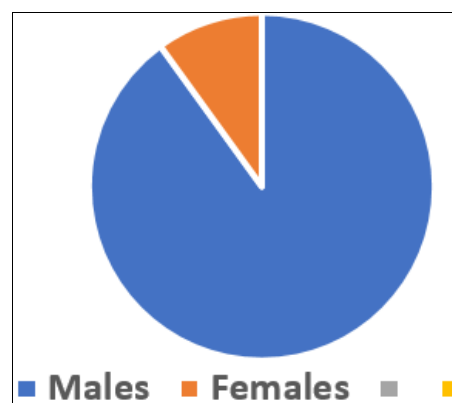


Fig 1: Sales

The fracture level was mid-shaft in 38 patients, proximal-shaft in 8 patients & distal-shaft in 4 patients. Fracture pattern was transverse in 28 & short oblique in 22 patients. The mean operative time was 48.5 ± 10.8 min

Union was achieved in all cases.

The mean time to union was 6.7 ± 1.5 weeks.

Delayed union occurred in 4 patients (2 radii & 2 ulnae) with no case of combined radius & ulnar delayed union. The 2 radii finally united at 14 weeks while the 2 ulnae finally united at 15 weeks

At final follow up, the mean supination range was 81.27 ± 4.1 , while the mean pronation range was 68.17 ± 3.03 .

The "Outcome Grading System" results were: 38 cases (76.0%) scored excellent, 10 cases (20%) scored good & 2 cases (4%) scored fair



Fig 2: Column1



Fig 3: Radiograph representing one case, A) Pre-operative AP, B) Pre-operative lateral, C) Final (3 months) AP, D) Final (3 months) lateral view

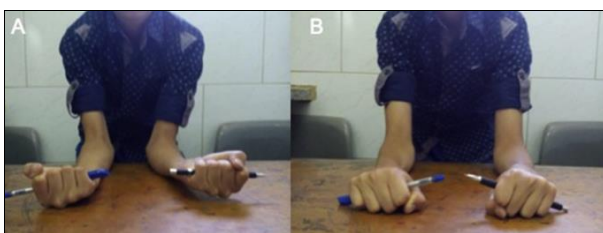


Fig 4: Clinical picture showing forearm supination-pronation forearm range in patient whose radiographs are shown in, a) Maximum supination, b) Maximum pronation

Discussion

Several advantages of ESIN have been reported in the literature, including decreased operative time, minimal soft tissue dissection, improved cosmesis, ease of implant removal, and early return to activity after implant removal. Delayed union and nonunion of the ulna after ESIN fixation of pediatric forearm fractures has been recently reported to be common. Study conducted by Shah *et al.* 23 they showed that the magnitude of radial bow was nearly completely restored with use of ESIN, but the location of the maximal radial bow was translated distally, despite that they found no difference

between plating and ESIN groups in regaining forearm rotation at their final follow up. In this study, the authors observed high union rate of the ulna compared to rates reported in the literature when using ESIN as well as achieving favorable functional outcome. Limitations to this study is that in order to generalize their results, further research would be needed that involve multiple centers with multiple surgeons performing this technique. In conclusion, the authors believe that hybrid fixation method in adolescent both-bones forearm fracture could be a viable option in managing these injuries & may reduce the problem of ulnar nonunion encountered when using ESIN in that age group.

Conclusion

Both-bone forearm fractures are common in children but rare in adults. While open reduction and internal fixation (ORIF) with plates is the traditional treatment, hybrid fixation combining elastic-stable intramedullary nailing (ESIN) for the radius and plating for the ulna is less frequently reported. Although non-operative management is viable for children over 10 years, they are more prone to malunion due to limited bone remodeling, making surgical intervention preferable.

This study, conducted over three years at Shridevi Institute of Medical Science and Research Hospital, evaluated hybrid fixation in 50 adolescents with both-bone forearm fractures. Results showed a high union rate with a mean union time of 6.7 weeks. Delayed union occurred in a few cases but resolved with extended follow-up. Functional outcomes were favorable, with 76% of patients achieving excellent results.

The hybrid fixation approach offers a promising alternative, potentially reducing ulnar nonunion issues seen with ESIN alone. Further multi-center studies are needed to validate these findings and refine treatment protocols.

Conflict of Interest: Not available

Financial Support: Not available

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How to Cite This Article

Gowri LY, Ahmed AI. Hybrid fixation for adolescent both-bones diaphyseal forearm fractures: Preliminary results of a prospective cohort study. *International Journal of Orthopaedics Sciences.* 2024; 10(3): 81-84.

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