



A STUDY OF RESULTS OF CONSERVATIVE AND OPERATIVE METHODS OF TREATMENT OF DIAPHYSEAL FRACTURES OF THE FOREARM IN CHILDREN

Orthopaedics

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ABSTRACT

Diaphyseal fracture of forearm is one of the common paediatric upper limb fracture encountered in orthopaedic practice. This prospective study consists of 50 paediatric patients and was conducted at tertiary care hospital. Closed reduction and POP application, open reduction and internal fixation with plates and screws, closed reduction and internal fixation with intramedullary nails were the different modes of treatment. Most of the cases had 22A3 type of fracture, 4 cases each had 22B3 and 22A2 type of fracture and one case each had 22A1 and 22C3 type of fracture. 33 cases were treated by CR + POP application. CR+IF with Plates were used in 11 patients and intramedullary nail fixation was done in 6 patients. In the treatment of forearm fractures by CR + POP application, out of 33 patients 28 patients had excellent results, 3 patients had good results and 2 patients had fair result. Out of 11 patients treated with Plates & Screws, 10 patients had excellent results and 1 patient had a poor result. Out of 6 patients treated with intramedullary nails, 4 patients had excellent results, 2 patients had good results. No significant association was observed between treatment and results. Majority of the complications like Displacement, Refracture angulation & malrotation were seen in CR + POP application. But most of them improved in the course of the treatment due to remodeling property in children. Superficial & deep infection cases (1 each) were seen in cases treated with OR+IF with plates & screws. No significant association was observed between treatment and complication. We concluded majority of both bone fractures of forearm in children can be managed conservatively by closed reduction and above elbow cast. Those cases which could not be managed by closed means may require operative treatment.

KEYWORDS

Diaphyseal Fractures; Fractures Of Both Bone Forearm;

1. INTRODUCTION:

As the acceleration of life has been on the upbeat in the younger generation these days, fracture of forearm bones has become more common in day to day practice. The treatment of diaphyseal fractures of forearm bones in children remains a significant surgical challenge. Treatment options range from conservative to surgical methods.

Conservative treatment includes Closed Reduction and POP application.^{1,2,4,42} Surgical treatment comprises of Closed Reduction & Internal Fixation with Intramedullary nails,^{3,79,31,32,33} & Open Reduction & Internal Fixation with plates.^{5,6,8,31,35,34}

Each of these proposed methods has its limitation in certain types of these fractures. Conservative methods poses problems like deformity, loss of motion, non union, mal-union etc. but whereas with recent advancement & development in the field of surgical instrumentation, surgical experience and improved rehabilitation techniques has put surgical treatment on the upper hand.

The purpose of this study is to determine the outcome of various methods of treatment of diaphyseal fractures of forearm in children and to analyze the complications and causes of failure.

2. AIMS AND OBJECTIVES:

This study intended for the following aims & objectives

- To analyze the various methods of management of diaphyseal fractures of forearm in children.
- Comparison between Conservative and Surgical management of forearm fractures in children.

3. METHODOLOGY:

a. Study design: prospective study

b. Sample size: 50 cases

c. Inclusion criteria: All closed diaphyseal fractures, Age less than 14 years

d. Exclusion criteria: Galeazzi fractures, Monteggia fractures, Open / Compound fractures

e. Pre-operative Assessment: 50 cases of diaphyseal fractures of forearm in children were treated at tertiary care Hospital by conservative to surgical methods. Closed reduction and POP application, open reduction and internal fixation with plates and screws, closed reduction and internal fixation with intramedullary nails were the different modes of treatment. The study was done on the children, aged up to 14 years of both sex with diaphyseal fractures of the forearm. Clearance was obtained from ethical committee

A careful history was elicited from the patient or from the attendants of the patients. A careful clinical assessment of skeletal or soft tissue injuries and general condition of the patient was done. The clinical examination gave a clue to determine whether the fracture was caused by direct or indirect violence. Examination was done to rule out any other fractures. Vital signs were recorded; vascular injuries; compartment syndrome & peripheral nerve injuries were carefully looked for.

Radiological assessment- Clinical diagnosis was confirmed by taking antero-posterior & lateral radiographs.

f. Type of Anesthesia: General anaesthesia

g. Approach: Closed reduction was tried under conservative methods. Fractures, which fail to reduce, or which fail to maintain reduction were immobilized in above elbow slab until the surgery. Analgesics were given to relieve pain.

Closed reductions of fractures were done under general anaesthesia under the guidance of the C - arm. The fractures which were not being able to treat by conservative methods were treated by nailing/plating. All the surgeries were done within 3 to 7 days of injury under general anaesthesia under aseptic conditions with minimal exposure of bones. Suction drain was fixed to a few cases.

h. Post-operative Management: Parental antibiotics were given for 3 days followed by oral antibiotics for 5 to 7 days. Active finger & shoulder movements were encouraged post operatively to promote better circulation and reduce edema. Postoperative radiographs were taken on the next day. Suture removal was done on the 10th days and the patients were discharged.

i. Follow up: Review of the patient was done for every 2 weeks for 3 to 4 months; followed by every monthly till 6 months and than 6 monthly till 2 years. Repeated radiographs were also taken to look for the callus formation. After 2nd week, POP cast conversion was done after confirmation of complete healing of surgical wound. After 6 to 8 weeks of post reduction, pop cast was removed & radiographs were repeated. After confirmation of fracture union clinically and radiologically, patient was encouraged for joint movements. Improvements in the range of movements were noted on every visit. Implant removal was done at the end of 2 years.

j. Statistical methods employ Statistical methods employed

Following statistical methods were employed in the present study.

1. Chi-square test

2. Contingency Coefficient analysis
3. Independent samples't' test
4. One-way ANOVA

4. RESULTS: This study consists of 50 cases of diaphyseal fractures of forearm in children treated by conservative and surgical modalities during the study period. All cases were available for follow-up.

A non-significant association was observed between age and sex revealing that pattern of distribution of scores of male and female subjects was same statistically [table 1]. However, when age alone considered, a significant difference was observed between frequencies of different age groups indicating that most of the cases were in between the age group of 10 and 14 years. The mean age of male patients was found to be 10.32 as compared to females whose mean age was 7.78 years. Males significantly had higher frequency (82%) compared to females (18%). 52% of the cases had left side injury, 46% of the cases had right side injury and only 2% of the cases had bilateral injury. Most of the cases reported had a fall (78%) as a mode of injury and only 22% had RTA as mode of injury.

A highly significant difference was observed in the type of fractures as most of the cases had 22A3 type of fracture, 4 cases each had 22B3 and 22A2 type of fracture and one case each had 22A1 and 22C3 type of fracture. Most of the cases reported had both bone fracture (84%), 4 cases had Green stick both bone fracture, 3 cases had fracture radius and remaining 1 case had fracture ulna. Significantly more number of fractures had occurred at middle 1/3rd compared to proximal and distal 1/3rd. 33 cases were treated by CR + POP application. Among which all patients <5 years were treated by CR, between the age group of 5 – 10 years 15 patients were treated and 13 patients in the age group of 10 to 14. None of the cases were treated by surgery below the age of 5. CR+IF with Plates were used in 2 patients in the age group of 5 –10 years and 9 patients in the age group of 10 to 14 years. Intramedullary nail fixation was done in patients in the age group of 10 to 14 years only.

The commonest type of fracture was the 22A3, which were seen in 40 patients. Majority of them were treated [31] by CR + POP, 6 patients were treated with OR+IF with Plates and screws, 1 patient was treated with rush nail & 2 with Square nail. All 4 patients with 22B3 type of fracture were treated with OR+IF with Plates & screws. Patients with 22A2 type of fracture were treated with CR+POP [2 patients] & CR +IF with K wire [2 patients]. 22A1 & 22C3 were one each & were treated with CR + IF with K wire and OR + IF with Plates & screws respectively.

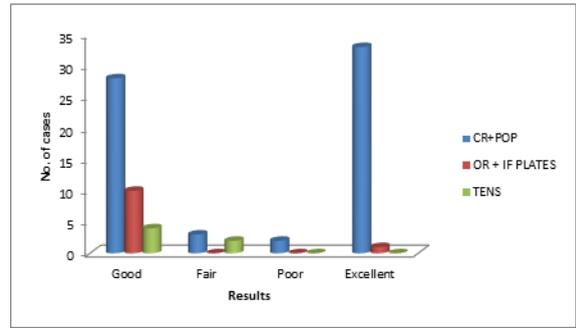
Significantly least time was taken for union by CR+POP method followed by CR+ nail fixation. Open reduction followed by internal fixation method took maximum time for union. Majority of the complications like Displacement, Refracture angulation & malrotation were seen in CR + POP application. But most of them improved in the course of the treatment due to remodeling property in children. Superficial & deep infection cases (1 each) were seen in cases treated with OR+IF with plates & screws. No significant association was observed between treatment and complication

No significant association was observed between treatment and supination. Patients treated with CR+POP application had restricted supination [normal 80-90 degrees] to 50 degrees [1 patient], 60 degrees [1 patient] & 80 degrees [1 patient]. One Patient treated with Plates & Screws had restricted supination to 60 degrees.

Out of 3 patients treated with CR + POP application, 1 patient each treated with OR + IF with plates & with K wire had restricted pronation to 70 degrees. While 1 patient treated with CR +POP application had restricted pronation to 80 degrees. All remaining cases resulted in full range of elbow movement [ROM: 85 –90 degrees] No significant association was observed between treatment and restricted pronation. 46 cases had no complaints with any type of management. 4 patients complained of pain on strenuous work {CR+POP application [1 patient], OR+IF with Plates [2 patients] & CR+IF with K wire [1 patient]}. No significant association was observed between complaints and treatment.

In the treatment of forearm fractures by CR + POP application, out of 33 patients 28 patients had excellent results, 3 patients had good results and 2 patients had fair result. Out of 11 patients treated with Plates & Screws, 10 patients had excellent results and 1 patient had a poor

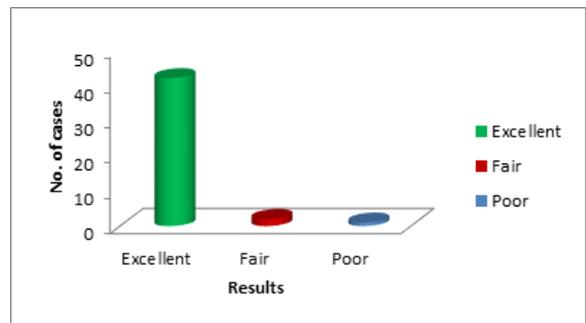
result. Out of 6 patients treated with intramedullary nails, 4 patients had excellent results, 2 patients had good results. No significant association was observed between treatment and results.



Graph showing results with treatment Results -Based on Price et al., criteria [Table1]

Results	Frequency	Percent
Excellent	42	84.0
Fair	2	4.0
Poor	1	2.0
Total	50	100.0

Based on the Price et al., criteria 42 patients results were excellent. 5 patient's results were good. 2 patients result were fair & 1 patients result was poor.



Graph Showing The Final Results

5. DISCUSSION AND ANALYSIS: 50 cases of diaphyseal fractures of forearm in children were treated by conservative to surgical methods. The study was done on the children, aged up to 14 years of both sex with diaphyseal fractures of the forearm.

- The mean **age** of the patients was 9.86 years (male -10.32 years and female - 7.78 years).
- In the study done on 14 children by Vainionpaa S Bostman O, Patiala H, Rokkanen P, the mean age of the patient was 12 years.⁶
- In the study done on 27 patients by Wyrsh B, Mencio GA, Green NE. The mean age of the patient at the time of injury was 11.5 years.⁸
- In the study done on 50 children by Kirkos JM, Beslikas T, Kapras EA, Papavasiliou VA, the mean age of the patients was 11 years.¹⁰ The incidence of forearm fracture [sex] was more among males compared to females. 41 were male patients and 9 were female patients.
- In the study of same fractures, Landin L A. analysed that forearm fractures were more common in male children.³⁹
- Majority of patient's **mode of injury** was fall on an outstretched hand. The other mode was road traffic accidents.
- In the study of forearm fractures in children, Tredwell SJ, Van Peteghen K, Clough M observed that the commonest mode of injury was fall followed by Road traffic accident.⁴³

Simple fractures involving both bones were the common **pattern of**

fracture seen in my study According to the Orthopaedic trauma classification [OTA] Type 22A3 [80%] is designated as the simple fracture of both bones of the forearm. 41 Other fractures seen were 22B3 [8%], 22A2[8%], 22A1[2%] and 22C3[1 %]. Comminution was rare.⁴¹

In our study of 50 cases, 33 cases were treated by **Closed Reduction and POP application**. Fracture union was seen in all cases between 8 to 12 weeks.

At the end of 3 months, 28 patients developed full range of movements with no functional deformity or complaints. 1 patient had 10-degree loss of pronation, 3 patients had 20-degree loss of pronation [Good] and only 1 patient had 30-degree loss of supination and 10-degree loss of pronation and also complained of pain on strenuous work [fair]

According to the criteria set by Price et al., 29 patients had excellent result, 2 had good result and 2 had fair results in treatment of forearm fractures in children by closed reduction and POP application.

- Johari AN and Simha M in 1999 studied 42 children with forearm fractures treated by closed reduction and plaster and assessed the remodelling capacity of the radial epiphyseal plate after union of fracture with angulation.¹
- Kerwyn Jones, M.D., M.S., & Dennis S. Weiner, M.D. evaluated the efficacy of closed reduction and long arm casting in 730 patients with closed fractures of the forearm. They believe that closed reduction and casting of pediatric forearm fractures remain the accepted standard method of treatment.⁴²

In our study, 6 cases were operated with **Closed Reduction and Internal Fixation**. Kirschner wires were used in 1 patient with both bones fracture, 2 patients with single bone fracture. 1 patient with fracture both bones distal third, operated with Kirschner wire developed pain on strenuous work and 1 patient with fracture ulna in the middle 1/3rd operated with Kirschner wire lost 20 degrees of pronation.

Rush pin was used in 1 patient with single bone fracture and Talwalkar square nails were used in 2 patients with both bone fractures.

According to the criteria set by Price et al, 4 patients had excellent results and 2 patients had good results.

- Roy D R, Crawford A H- in 1990 studied diaphyseal fractures of the radius and ulna, treated them by closed reduction and immobilization in a long arm cast. Irreducible fractures can be treated operatively and intramedullary fixation was preferred usually for the age group of more than 10 years.³
- Yung S H, Lam C Y, Ng K W, Maffulli N, Cheng J C. in 1998 studied percutaneous intramedullary Kirchner wiring for displaced diaphyseal forearm fractures in 72 children less than 14 years. They concluded that K wiring is a convenient, effective and safe operation with minimal complication.⁹
- Sun Y Q, Penna J, Haralabatos SS, Crion W V in 2001 studied 24 children with both bones forearm fractures treated with Rush pins and Kirschner wires. After follow up for 32 months, all fractures healed well with no complication and with full range of movements.⁷
- Scott D. Shoemaker, M.D., Comstock, M .D., Mubarak, M.D., Wenger, M.D., & Chambers, M. D. did a retrospective review which evaluates the efficacy of standard intramedullary Kirschner wires for the treatment of open or unstable diaphyseal forearm fractures in 32 children.³²
- John M. Flynn, M. D., & Peter M. Waters, M. D in 1996, studied on 17 children with diaphyseal both bones forearm fractures with single bone fixation.³³

In my study, 11 cases of both bone forearm fractures were treated by **Open Reduction and Internal Fixation** with plates and screws.

The time taken for fracture union was 8-12 weeks. 9 patients developed full range of movements with no functional deformity or complaints.

1 patient developed superficial infection and complained of mild pain on strenuous work [good] and 1 patient developed deep infection, 20 degrees loss in both supination and pronation with pain on daily work.[poor]. 9 cases had excellent results 1 patient had good results and 1 patient had poor results.

According to the criteria set by Price et al, 9 patients had excellent results and 1 patient had good result and 1 patient had poor results with open reduction and internal fixation with plates and screws.

- Wyrsch B, Mencio GA, Green N E, in 1996 studied 27 displaced diaphyseal fractures treated by Open reduction and internal fixation. After 39 months of follow-up, it was concluded that Open reduction and internal fixation is indicated and safely performed in children with unstable or both bone fracture forearm when closed nails fail.⁸
- Chapman M W, Gordan J E, Zissimos A G, in 1989 treated 87 patients of forearm fractures with A O dynamic compression plate. The results were 98 percentage union .92 percent excellent or satisfactory function.⁵
- Kirkos J M, Beslikas T, Kapars E A, Papavasiliou V A did a retrospective study on 50 children with unstable diaphyseal both bones forearm fractures where closed reduction was a failure, and followed Open reduction and internal fixation to a single bone was done. Result proved to be excellent after follow up including good alignment of ulna.¹⁰
- William L. Vander Reis, Md., Norman Y, Otsuka, MD, Moroz , MD.& Mah M.D. Intramedullary nailing versus plate fixation for unstable forearm fractures in children.³¹
- Brad Wyrsh, M. D., Gregory A. Mencio, M. D., & Green, M .d, studied 27 displaced diaphyseal forearm fractures treated by open reduction and internal fixation. Anatomic or near anatomic reduction was achieved with compression plates and intramedullary nails.³⁴

In the study of 50 patients, 5 patients were below the age of 5 years. All the 5 patients were treated with CR & POP application. There were 17 patients in the age group of 5-10 years in which 15 of the patients were treated with CR & POP application and 2 of the patients were treated with OR+IF with Plates & Screws after an attempt for Percutaneous pinning was made.

There were 28 patients in the age group of 10-14 years in which 13 were treated with CR & POP application, 9 patients were treated with OR+IF with Plates & Screws and 6 patients were treated with Intramedullary nailing.

The clinical outcome was graded with a scale used by **Price et al**⁴⁴ and similar to that proposed by Daruwalla.⁴⁵

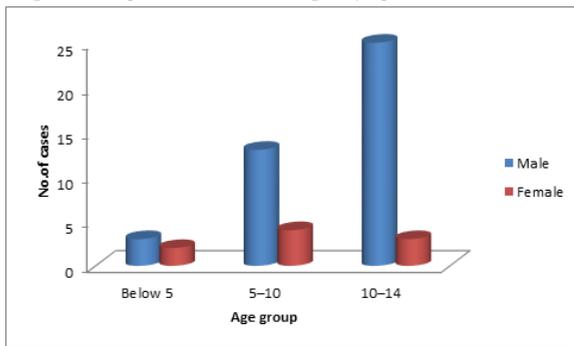
6. CONCLUSION:

Present study consists of 50 cases of diaphyseal fractures of forearm in children treated conservatively and surgically. Majority of both bone fractures of forearm in children can be managed conservatively by closed reduction and above elbow cast. Good to excellent results can be achieved by conservative method. Those cases which could not be managed may require operative treatment.

Distribution of sample by age and sex [Table 2]

Age		SEX		Total
		Male	Female	
Below 5	Frequency	3	2	5
	Percent	7.3%	22.2%	10.0%
5-10	Frequency	13	4	17
	Percent	31.7%	44.4%	34.0%
10- 14	Frequency	25	3	28
	Percent	61.0%	33.3%	56.0%
Total	Frequency	41	9	50
	Percent	100.0%	100.0%	100.0%
Mean±sd	9.88±2.92	7.879±3.48	9.52±3.12	

Graph showing Distribution of sample by age and sex



[TABLE 3 Treatment & Age Cross tabulation]

Treatment	Age			Total	
	Below 5	5-10	10-14		
CR+POP	Frequency	5	15	13	33
	Percent	100.0%	71.43%	54.17%	66.0%
OR + IF PLATES	Frequency		2	9	11
	Percent		9.52%	37.5%	22.0%
Nail	Frequency	0	4	2	6
	Percent		19.05	8.33	12
Total	Frequency	5	21	24	50
	Percent	100.0%	100.0%	100.0%	100.0%
Mean±sd	9.16±3.08				

[TABLE 4 Cross tabulation of Treatment & Type of fractures]

Treatment		Type of fracture Total					Type of fracture Total	Mean ±sd
		22A3	22B3	22A2	22A1	22C3		
CR+POP	F	31		2			33	6.6±20.27
	%	77.5%		50.0%			66.0%	
OR + IF PLATES	F	6	4			1	11	2.2±5.90
	%	15.0%	100.0%			100.0%	22.0%	
Nail	F	3		2	1		6	1.2±2.53
	%	7.5		50	100		12	
Total	F	40	4	4	1	1	50	
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	

[Table 5 - Comparison of Results with respect to treatment {Price et al criteria}]

Treatments	RESULTS					Total
	Excellent	Good	Fair	Poor		
CR+POP	Frequency	28	3	2		33
	Percent	66.67%	60.0%	100.0%		66.0%
OR + IF PLATES	Frequency	10			1	11
	Percent	23.81%			100.0%	22.0%
Nail	Frequency	4	2			6
	Percent	9.52	40			
Total	Frequency	42	5	2	1	50
	Percent	100.0%	100.0%	100.0%	100.0%	100.0%
Mean±sd	14±14.28	1.67±1.29	0.67±1.15	0.33±0.58	16.67±15.85	

Abbreviations:

CR + POP – Closed reduction followed by Plaster of Paris; OR+IF- Opem Reduction followed by Internal Fixation;

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