Review Article

POSI
IJPO

# Outcomes in Paediatric Proximal Third Forearm Fractures: A Systematic Review

Nathan McKenzie B.S.[2], Connor Zale M.D.[1], Ryan Nguyen B.S.[3], Kevin Krul M.D.[1]

Dr. Nathan McKenzie

Dr. Connor Zale

Dr. Ryan Nguyen

Dr. Kevin Krul

**Address of Correspondence**
Dr. Connor Zale
Tripler Army Medical Center. 1 Jarrett White Rd. Medical Center. Honolulu, HI. 96859.
**Email:** Connor.zale11@gmail.com

[1]Tripler Army Medical Center. 1 Jarrett White Rd. Medical Center. Honolulu, HI. 96859.
[2]University of Oklahoma College of Medicine. 800 Stanton L Young Blvd. Oklahoma City, OK. 73117.
[3]John A. Burns School of Medicine. University of Hawaii. 651 lalo St, Honolulu, HI 96813.

DOI: https://doi.org/10.13107/ijpo.2024.v10.i03.198
www.ijpoonline.com | Online ISSN: 2455-3905
© The Author(s). 2024 Open Access. This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (https://creativecommons.org/licenses/by-nc/4.0/), which permits unrestricted use, distribution, and non-commercial reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The Creative Commons Public Domain Dedication waiver (http://creativecommons.org/publicdomain/zero/1.0/) applies to the data made available in this article, unless otherwise stated.

## Abstract

**Objective:** To analyze initial treatment failure, functional and radiographic outcomes following non-operative management of Paediatric third proximal forearm fractures.

**Methods:** A search was performed on PUBMED/MEDLINE, Cochrane Database and Embase on 28 January 2024. Search keywords were "Paediatric, proximal, forearm and fracture". Articles were reviewed for non-operative management of proximal forearm fractures. Articles were reviewed for acceptable angulation for successful treatment, rate of conversion to operative management or remanipulation, functional outcomes and final radiographic angulation.

**Results:** 181 articles were obtained from a literature search. 10 articles had incomplete data. 10 articles reported the rate for initial treatment failure. 4 articles reported individual patient functional outcomes. 3 articles reported individual residual angulation.

There were 392 cases of proximal forearm fractures. The rate of initial treatment failure which required remanipulation or surgery ranged from 0-83.8%. Individual functional outcomes were reported for 22 patients. The average age was 10.9±3.9 years old. 16/22 cases had full range of motion. The 6 cases with limited range of motion had residual angulation of 5-15° (11.5±4.2). 3/5 cases with ≥15° of residual angulation had full range of motion.

**Conclusion:** The rate of initial non-operative treatment failure ranged from 0-83.8% for proximal forearm fractures. Families should be advised on the high rate of failure for initial non-operative management and the possible need for remanipulation or surgery. Patients that are 10 years and older are at an increased risk for loss of reduction and possible need for surgical treatment.

**Keywords:** Both bone, Proximal third forearm, Paediatric forearm fracture

## Introduction:

Forearm fractures are common injuries in children. Distal forearm fractures accounted for 26% of fractures reported by Hedstrom et al. [1]. Proximal forearm fractures were significantly fewer and accounted for 3% of fractures. Closed reduction and immobilization is the initial treatment for these injuries. There are various recommendations on acceptable angulations for non-operative treatment. Noonan and Price recommended proximal third angulation <15° in children younger than 9 years old and <10° in children greater than 9 years old [2]. Pace presented an acceptable angulation of <15° in girls ≤8 years old and boys ≤10 years old. Pace recommended <10° angulation in girls>8 years old and boys >10 years old [3]. The rate of initial treatment failure for non-operative management of proximal forearm fractures is unknown. The effect of residual angulation on patient outcomes for proximal forearm fractures is also unclear. The purpose of this systematic review was to analyze the rate of treatment failure following non-operative management of Paediatric third proximal forearm fractures.

Submitted: 14/11/2024; Reviewed: 20/11/2024; Accepted: 04/12/2024; Published: 10/12/2024

Methods: A literature search was performed on PUBMED/MEDLINE, Cochrane Database and Embase on 28 January 2024. Search keywords were "Paediatric, proximal, forearm and fracture". Articles were reviewed for non-operative management of proximal third forearm fractures. Articles that reported Monteggia fractures were excluded. Case reports, articles not written in English, technique guides and articles with initial surgical management were excluded. Articles were reviewed for acceptable angulation for successful treatment, rate of conversion to operative management or remanipulation, functional outcomes and final radiographic angulation.

Results: A literature search was conducted and a total 181 articles underwent initial screening. 20 articles met inclusion criteria. 10 articles had incomplete data. 10 articles reported the rate for initial treatment failure [4–13] (Fig. 1).

There was a total of 392 cases of proximal forearm fractures reported in the included studies. 4 of these articles reported the functional outcomes for individual patients in the study (Carey, Creasman, Price, Zionts), and 3 reported patients' residual angulation after completion of conservative management of their fracture (Carey, Price, and Zionts) [5, 6, 10, 11].

The rate of initial treatment failure which required remanipulation or surgery ranged from 0-83.8% (Table 1). Individual functional outcomes were reported for 22 patients. The average age was 10.9±3.9 years old. There were 5 female patients and 11 male patients. 6 cases did not have their gender reported. 16/22 cases had full range of motion. The 6 cases with limited range of motion had residual angulation of 5-17 (11.5±4.2) (Table 2). One patient with limited range of motion reported difficulty with bowling and typing. There were 5 cases with ≥15° or residual angulation. 3/5 cases with ≥15° of residual angulation had full range of motion.

| Article | Non-operative Treatment Failure | Failure Rate (%) |
|---|---|---|
| Bowman | 57/68 | 83.8 |
| Carey | 0/5 | 0 |
| Creasman | 3/6. | 50 |
| Dittmer | 2/14. | 14.3 |
| Lyman | 2/8. | 25 |
| Neal | 1/14. | 7.1 |
| Price | 0/5 | 0 |
| Seefried | 3/12. | 25 |
| Williams | 66/276 | 23.9 |
| Zionts | 2/6. | 33.3 |

**Table 1:** The number of cases that failed treatment and overall failure rate is displayed above for the included studies.

**Discussion:**

Both bone forearm fractures are a common orthopaedic injury among Paediatric patients. However, there is limited information on patient outcomes and range of motion following non-surgical treatment of these fractures. There are even fewer studies that report patient outcomes following proximal one-third forearm fractures. The goal of this literature review was to summarize the results of proximal forearm fractures treated non-operatively and report the rate of failure requiring remanipulation or surgery. Among the 10 studies that were included, there was a failure rate of 0-83.8% in the non-surgical treatment of Paediatric both bone forearm fractures.

The studies by Carey et al, Price et al, and Zionts et al reported

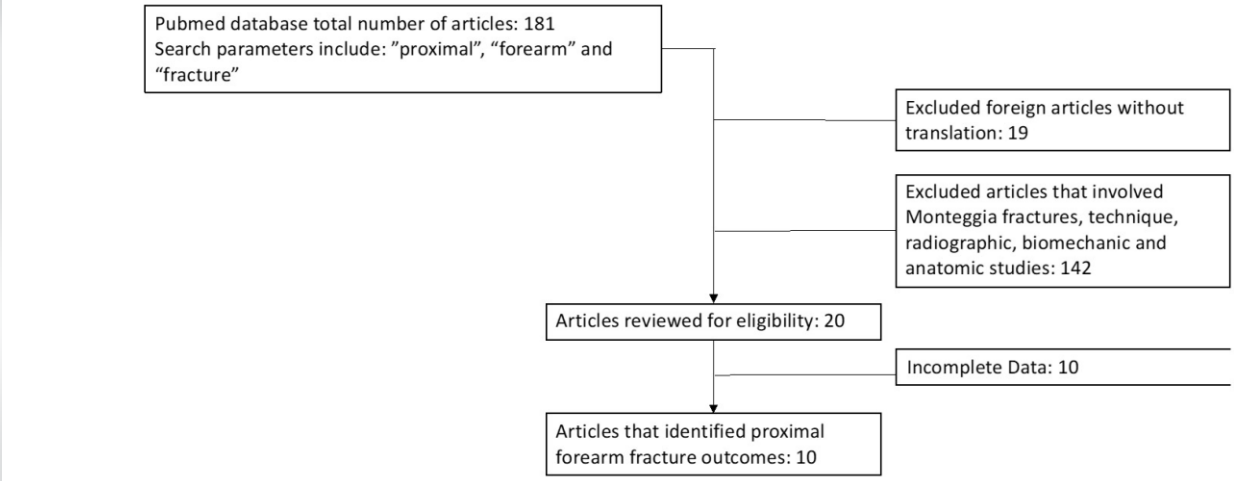


**Figure 1:** PRISMA Results Breakdown

| Article | Patient | Age | Gender | Pre-reduction Angulation | Post-reduction Angulation | Range of Motion | Outcome | Residual Angulation |
|---|---|---|---|---|---|---|---|---|
| Carey | 1 | 9 | F | N/A | 20 | 0 | No deficits | 10 |
| Carey | 2 | 9 | M | N/A | 20 | 0 | No deficits | 10 |
| Carey | 3 | 8 | M | N/A | 20 | 0 | No deficits | 5 |
| Carey | 4 | 6 | F | N/A | 20 | 0 | No deficits | 10 |
| Carey | 5 | 6 | M | N/A | 15 | 0 | No deficits | 20 |
| Creasman | 1 | 10 | N/A | 10 to 30 | 10 to 30 | Full | N/A | N/A |
| Creasman | 2 | 17 | N/A | 10 to 30 | >10 | Full | N/A | N/A |
| Creasman | 3 | 6 | N/A | >10 | >10 | Full | N/A | N/A |
| Creasman | 4 | 10 | N/A | 10 to 30 | 10 to 30 | Full | N/A | N/A |
| Creasman | 5 | 13 | N/A | 10 to 30 | >10 | Full | N/A | N/A |
| Creasman | 6 | 17 | N/A | 10 to 30 | >10 | Full | N/A | N/A |
| Price | 1 | 5 | F | N/A | N/A | 30 | N/A | 10 |
| Price | 2 | 7 | F | N/A | N/A | Full | N/A | 15 |
| Price | 3 | 7 | F | N/A | N/A | 90 | N/A | 10 |
| Price | 4 | 9 | M | N/A | N/A | Full | N/A | 8 |
| Price | 5 | 16 | M | N/A | N/A | Full | N/A | 17 |
| Zionts | 1 | 14 | M | N/A | N/A | 40 | Fair | 17 |
| Zionts | 2 | 14 | M | N/A | N/A | Full | Excellent | 7 |
| Zionts | 3 | 14 | M | N/A | N/A | 20 | Good | 5 |
| Zionts | 4 | 14 | M | N/A | N/A | 35 | Fair | 12 |
| Zionts | 5 | 15 | M | N/A | N/A | 5 | Excellent | 15 |
| Zionts | 6 | 15 | M | N/A | N/A | Full | Good | 5 |

**Table 2:** Patient demographics, initial angulation, range of motion, outcome and residual angulation are displayed above for the included studies.

patient outcomes. None of the patients in the studies by Carey et al and Price et al underwent remanipulation despite having a large residual angulation of up to 20°. 6 of these 16 patients were found to have a loss in their range of motion. One patient reported having difficulty performing certain tasks that require ample pronation and/or supination of the forearm. This patient had a residual angle of 10°. The residual angulation that results in functional limitations is unclear in proximal forearm fractures.

Three of the studies determined a correlation between patient age and treatment outcome [4, 10, 12]. Bowman et al and Williams et al reported patients over the age of 10 were more likely to fail conservative treatment and require surgery. Bowman also specified that this was true for both male and female patients. In the study by Price et al, none of the patients were identified as failing conservative treatment. Price reported that patients less than 10 years old had a higher likelihood of remodeling their residual deformities.

Limitations of this study include the small number of patients with reported outcomes and the variability for acceptable angulation of proximal fractures between studies. The Bowman study had the highest treatment failure rate, with 57 of the 68 patients not meeting acceptable angulation criteria. The criteria for acceptable angulation were smaller than other studies with ≤10° for females ≤8 years old and males ≤10 years old, and ≤10° for females >8 years old and males >10 years old. The Neal et al study had criteria for acceptable angulation of ≤15° for proximal forearm fractures. Only 1 of the 14 patients with a proximal both bone fracture was determined to have failed conservative treatment with an extended arm cast in the study by Neal et al.

Given the wide range of reported failure following non-surgical management, families of patients with proximal forearm fractures should be advised about the possibility for remanipulation or surgery. Older patients have a higher probability requiring further procedures due to their decreased remodeling potential.

**Conclusion:**

The rate of initial non-operative treatment failure ranged from 0-83.8% for proximal forearm fractures. Families should be advised on the high rate of failure for initial non-operative management and the possible need for remanipulation or surgery. Patients that are 10 years and older are at an increased risk for loss of reduction and possible need for surgical treatment.

## References


1. Hedström EM, Svensson O, Bergström U, Michno P (2010) Epidemiology of fractures in children and adolescents. Acta Orthop 81:148–153. https://doi.org/10.3109/17453671003628780

2. Noonan KJ, Price CT (1998) Forearm and distal radius fractures in children. J Am Acad Orthop Surg 6:146–156.

https://doi.org/10.5435/00124635-199805000-00002

3. Pace JL (2016) Paediatric and Adolescent Forearm Fractures: Current Controversies and Treatment Recommendations. J Am Acad Orthop Surg 24:780–788. https://doi.org/10.5435/JAAOS-D-15-00151

4. Bowman EN, Mehlman CT, Lindsell CJ, Tamai J (2011) Nonoperative treatment of both-bone forearm shaft fractures in children: predictors of early radiographic failure. J Paediatr Orthop 31:23–32.

https://doi.org/10.1097/BPO.0b013e318203205b

5. Carey PJ, Alburger PD, Betz RR, et al (1992) Both-bone forearm fractures in children. Orthopaedics 15:1015–1019. https://doi.org/10.3928/0147-7447-19920901-04

6. Creasman C, Zaleske DJ, Ehrlich MG (1984) Analyzing forearm fractures in children. The more subtle signs of impending problems. Clin Orthop Relat Res 40–53

7. Dittmer AJ, Molina D, Jacobs CA, et al (2019) Paediatric Forearm Fractures Are Effectively Immobilized With a Sugar-Tong Splint Following Closed Reduction. J Paediatr Orthop 39:e245–e247.

https://doi.org/10.1097/BPO.0000000000001291

8. Lyman A, Wenger D, Landin L (2016) Paediatric diaphyseal forearm fractures: epidemiology and treatment in an urban population during a 10-year period, with special attention to titanium elastic nailing and its complications. J Paediatr Orthop B 25:439–446.

https://doi.org/10.1097/BPB.0000000000000278

9. Neal KM, Osterbur TA, Kiebzak GM (2020) Improving Quality in the Treatment of Paediatric Forearm Fractures: Minimizing the Need for Repeat Intervention With Long-arm Extension Casting. J Paediatr Orthop 40:329–333. https://doi.org/10.1097/BPO.0000000000001519

10. Price CT, Scott DS, Kurzner ME, Flynn JC (1990) Malunited forearm fractures in children. J Paediatr Orthop 10:705–712.

https://doi.org/10.1097/01241398-199011000-00001

11. Zionts LE, Zalavras CG, Gerhardt MB (2005) Closed treatment of displaced diaphyseal both-bone forearm fractures in older children and adolescents. J Paediatr Orthop 25:507–512.

https://doi.org/10.1097/01.bpo.0000158005.53671.c4

12. Williams K, Whyte N, Carl JR, et al (2023) Predictors for operative treatment in Paediatric proximal third both-bone diaphyseal forearm fractures in children include age and translation, but not initial angulation. J Child Orthop 17:156–163. https://doi.org/10.1177/18632521231156941

13. Seefried S, Chin-Goh K, Sahakian V, et al (2022) Paediatric forearm fractures manipulated in the emergency department: incidence and risk factors for re-manipulation under general anaesthesia. N Z Med J 135:60–66. https://doi.org/10.26635/6965.5665


**Declaration of patient consent :** The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

**Conflict of interest:** Nil **Source of support:** None


### How to Cite this Article

McKenzie N, Zale C, Nguyen R, Krul K | Outcomes in Paediatric Proximal Third Forearm Fractures: A Systematic Review | International Journal of Paediatric Orthopaedics | September-December 2024; 10(3): 2-5.