## ADVANCES

# Minimally angulated pediatric wrist fractures: Is immobilization without manipulation enough?

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**ABSTRACT**

**Background:** Emergency department (ED) manipulation of complete minimally angulated distal radius fractures in children may not be necessary, due to the excellent remodeling potential of these fractures.

**Objectives:** The primary objective of this study was to determine the proportion of minimally angulated distal radius fractures managed in the ED with plaster immobilization that subsequently required manipulation. Our secondary objective was to document, at follow-up, changes in angulation for each wrist fracture.

**Methods:** This retrospective cohort study reviewed consecutive records of all children with bi-cortical minimally angulated (≤15° of angulation in the sagittal plane and ≤0.5 cm of displacement) distal metaphyseal radius fractures, alone or in combination with distal ulnar fracture. Details of treatment, radiographic findings, and clinical outcomes during the subsequent orthopedic follow up were recorded.

**Results:** Of 124 patients included in the analysis, none required manipulation after their ED visit. All but 14 (11.3%) fractures were angulated ≤20° within the follow-up period. Two (1.6%) fractures that were initially angulated ≤15° progressed to 30°–35°, but remodeled within 2 years to nearly perfect anatomic alignment. By 6 weeks post-injury, no patients had clinically apparent deformity and all had normal function.

**Conclusions:** Minimally angulated fractures of the distal metaphyseal radius managed in plaster immobilization without reduction in the ED are unlikely to require future surgical intervention.

**Key words:** pediatrics; injury; fracture

**RÉSUMÉ**

**Contexte :** Les manipulations à l'urgence de fractures complètes du radius distal à angulation minimale chez les enfants peuvent ne pas être nécessaires, en raison de l'excellent potentiel de remodelage de ce type de fracture.

**Objectifs :** Le principal objectif de cette étude était de déterminer la proportion de fractures du radius distal à angulation minimale traitées à l'urgence à l'aide d'une immobilisation plâtrée

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ayant nécessité une manipulation par la suite. Notre objectif secondaire était de documenter, lors du suivi, les changements dans l'angulation pour chaque fracture du poignet.
**Méthodes :** La présente étude de cohortes rétrospective a examiné les dossiers consécutifs de tous les enfants présentant des fractures bicorticales de la métaphyse du radius distal à angulation minimale (≤15° d'angulation sur le plan sagittal et ≤0,5 cm de déplacement), seules ou combinées à une fracture du cubitus distal. Les détails du traitement, les constatations radiographiques et les résultats cliniques au cours du suivi orthopédique furent notés.
**Résultats :** Parmi les 124 patients inclus dans l'analyse, aucun n'eut besoin d'une manipulation après sa visite à l'urgence. Toutes les fractures sauf 14 d'entre elles (11,3 %) étaient angulées à ≤20° au cours de la période de suivi. Deux fractures (1,6 %) qui étaient angulées au départ à ≤15° progressèrent vers une angulation de 30°–35°, mais aucun patient ne présentait de difformité apparente et tous avaient une fonction normale.
**Conclusions :** Les fractures à angulation minimale de la métaphyse du radius distal traitées à l'aide d'une immobilisation plâtrée sans réduction à l'urgence sont peu susceptibles de nécessiter une intervention chirurgicale ultérieure.

## Introduction

Pediatric wrist injuries are a common presenting complaint in the emergency department (ED).[1] Most of these injuries involve fractures of the radial metaphysis, alone or in combination with the distal ulna,[2] and are either buckle, greenstick or complete fractures. The initial management of greenstick and complete fractures with minimal angulation varies.[1–4] Although most ED physicians would only splint or cast these fractures, approximately 25% would manipulate these fractures before casting, even in the absence of clinical deformity.

Minimally angulated distal radius fractures treated without manipulation may occasionally have minor residual angulation, but there is no published information suggesting that functional problems or patient dissatisfaction is likely in these cases. Rather, there is evidence showing excellent remodelling, function and satisfaction with such injuries.[2–7] We believe it is unnecessary to perform manipulative procedures that are painful, costly, often require sedation, and consume substantial ED resources. Therefore, initial management of these injuries at the Hospital for Sick Children in Toronto, Ont., entails plaster immobilization without ED reduction.

Our objective was to assess our treatment protocol by identifying changes in angular deformity for minimally angulated distal radius fractures managed only with plaster immobilization, and to document cases requiring subsequent manipulation during the first 4–6 weeks of healing.

## Methods

### *Study population and design*

This retrospective cohort study was performed at a large urban tertiary care university-affiliated children's hospital. Two research assistants, trained in specific study abstraction methods, identified potential study subjects by selecting all patients with codes cited in either the *International Classification of Diseases, 9th revision (Clinical Modification)* (ICD-9-CM) or the *Canadian Enhancement to the International Statistical Classification of Diseases and Related Health Problems*, 10th rev (ICD-10-CA) that were compatible with distal radius injury (Table 1) based on coded discharge diagnoses for the 5-year period from 1999 to 2004. The research assistants (B.S. and S.Y.) reviewed records independently, retrieved pertinent information, and measured fracture angulation and displacement using standard techniques[8] and the tools available on the picture

**Table 1. ICD codes used for identifying patients eligible for the study**

| Diagnosis | ICD-9-CM (prior to 2002) | ICD-10-CA (2002–2004) |
|---|---|---|
| Wrist fracture or injury | 923.21, 959.3 | S699, T922, S62.800, S69.7, S69.8, S69.9 |
| Forearm fracture or injury | 813.4, 813.8 | S52.700, S52.800, S52.900, S59.8 |
| Radius fracture | 813.21, 813.42, 813.81 | S52.300, S52.580, S52.590, |
| Ulna fracture | 813.22, 813.43, 813.82 | S52.200 |
| Radius and ulna fracture | 813, 813.2, 813.23, 813.4, 813.44, 813.8, 813.83 | S52.401, S52.600 |
| Colles fra cture | | S52.500, S52.501 |

ICD = International Classification of Diseases; ICD-9-CM = *International Classification of Diseases, 9th revision (Clinical Modification);* ICD-10-CA = *Canadian Enhancement to the International Statistical Classification of Diseases and Related Health Problems*, 10th rev



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archiving and communications system (PACS). Inter-rater reliability of the 2 research assistants was assessed on a random sample of 50 radiographs from the study pool.

Eligible patients included all skeletally immature children (i.e., girls <11 years of age and boys <13 yr with open growth plates on x-ray) who presented to the ED with minimally angulated and displaced bi-cortical fractures of the distal metaphyseal radius in isolation or in association with distal ulnar fractures. Children were excluded if they had pre-existing musculoskeletal disease, coagulopathies, congenital anomalies of the wrist, recent (≤3 mo) surgery involving the affected wrist, open or growth plate fractures. Children were also excluded if their wrist radiographs were not stored digitally on the hospital's PACS, or if they did not return to the study institution's orthopedic clinic for follow-up.

### *Definitions*

"Minimal angulation and displacement" was defined as ≤15º of angulation in the sagittal plane and ≤0.5 cm of displacement.[2,3] The area on the radiograph that defined the "distal radius and ulna metaphysis" was identified by a square with the same length as the widest part of the radius and ulnar growth plates.[9]

### *Follow-up*

Eight orthopedic surgeons share a common fracture clinic practice at the study institution. Established treatment and follow-up protocols were applied to all cases seen in this clinic. Surgical intervention was defined as closed or open manipulation with or without fixation of the wrist fracture. Closed manipulation under anesthesia was considered if angulation progressed to >20º within a week of injury. Open surgical intervention was indicated if there was clinically apparent deformity (assessed by comparing the skin contour to the opposite arm) and/or functional impairment upon completion of the 4–6-week follow-up period. Clinically apparent deformity or functional impairment was determined by the examining surgeon. Range of motion was assessed by comparing wrist flexion and extension, elbow flexion and extension, and forearm pronation and supination to the contralateral arm. Strength was assessed by having the child push the examiner's hand with the child's palm open and wrist in the extended position.

### *Data collection*

Information recorded for eligible patients from the first ED visit included patient demographics, mechanism of injury, presence and location of swelling, tenderness and deformity, neurovascular exam, diagnosis and management. All subsequent ED visits were reviewed for reason(s) of visit, repeated radiographs, and change of diagnosis and or management. Each record corresponding to an orthopedic clinic follow-up visit was examined for post injury date of visit, details and results of repeated radiographs, the orthopedic physician's diagnosis, any changes of immobilization device, total period of immobilization, clinical and/or radiographic deformity of the fractured arm, and any information available on function of the fractured arm. The frequency and indication for surgical intervention that resulted from follow-up visits to the ED or orthopedic clinic were recorded. All eligible patient radiographs were analyzed by the research assistants in conjunction with official radiology reports to determine if the distal radius and ulnar growth plates were open, the location(s) of the fracture(s), degree of angulation in the sagittal plane, amount of displacement, and presence of callus formation. All data were entered into SPSS 13.0 for Windows.

### *Outcome measures*

The primary outcome measure was the proportion of children who required surgical intervention during the 4–6-week follow-up period. The secondary outcome was change in radiologic angulation during the follow-up period.

### *Data analysis*

Our sample size of 124 was calculated using the proportion and 95% confidence interval (CI) estimate equation, assuming 3% of fractures would require surgical intervention after ED discharge. This was based on a survey of orthopedic surgeons and emergency physicians, which revealed a mean estimate of 3% of wrist fractures that would require future manipulation. Proportions, measurements of central tendency, and diagrammatic representations of angulation changes over time were reported as appropriate. In addition, for inter-rater reliability, an intra-class correlation coefficient with respective 95% CI was calculated. Statistical analyses were performed using SPSS 13 for Windows. The study was approved by the institutional Human Ethics Review Board

## Results

During the study period, 2533 patients presented with distal metaphyseal radius fractures. Figure 1 shows that 124 of these were eligible and were not manipulated in the ED before cast immobilization. Mean age was 8.7 years (standard deviation [SD] 3.30), and 53% were male. The most com-



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mon injury mechanisms included falls in 103 cases (83.1%), direct impact to the arm in 14 cases (11.2%), twisting injuries in 4 (11.2%) and "unknown" mechanism in 3 (2.4%).

All patients were initially splinted with a plaster of Paris volar or dorsal splint for 1 week until their first orthopedic clinic visit. Following this visit, 15 (12.0%) remained in a splint, 64 (51.6%) were placed in a short arm cast, and 45 (36.2%) had a long arm cast applied for the duration of therapy. All but 2 children were immobilized for 4 weeks. These 2 were immobilized for 6 weeks, due to progression of radiological angulation between the 2nd and 4th weeks of follow-up. No patients required surgical intervention or had clinically apparent physical deformity or functional impairment at 6 weeks.

The mean number of radiographs per patient was 3.45 (SD 0.45). The 2 research assistants demonstrated a high inter-rater reliability of angulation measurements with an intra-class correlation coefficient of 0.92 (95% CI, 0.86–0.95). Figure 2a, Figure 2b and Figure 2c summarize changes in angulation that occurred in patients with different initial angulation. Figure 3 highlights the 14 (11.3%) patients in whom angulation progressed to ≥20°. None of the 67 patients with an initial angulation of ≤9.9° progressed to ≥20°; however, 14 (24.6%) of 57 patients with an initial angulation of 10°–15° progressed to 20.0°–29.9° and 2 patients (3.5%) progressed to 30°–35° within the follow-up period. Long-term radiographic follow-up of the latter 2 patients (aged 5 and 11 yr) demonstrated remodelling to within 5° of perfect anatomic alignment within 2 years, and neither patient had functional impairment or visible deformity at this time.

## Discussion

In this study, none of the children with minimally angulated distal metaphyseal radius fractures required surgical intervention, and all were free of clinical deformity and functional impairment in follow-up. Therefore, manipulation of these fractures in the ED is likely unnecessary, especially given that fracture manipulation can lead to patient discomfort, safety concerns related to anesthesia,[10] added costs and prolonged time in the ED.

The 2 patients in whom angulation progressed from 15° to 30°–35° ultimately remodelled to almost perfect anatomic alignment. This is consistent with what is known about the remodelling potential of the distal radius metaphysis. Fractures in this area have great capacity for angular remodelling, and even when remodelling is incomplete it is uncommon to see residual functional or cosmetic deformity.[7] Therefore, not only is surgical manipulation unnec-

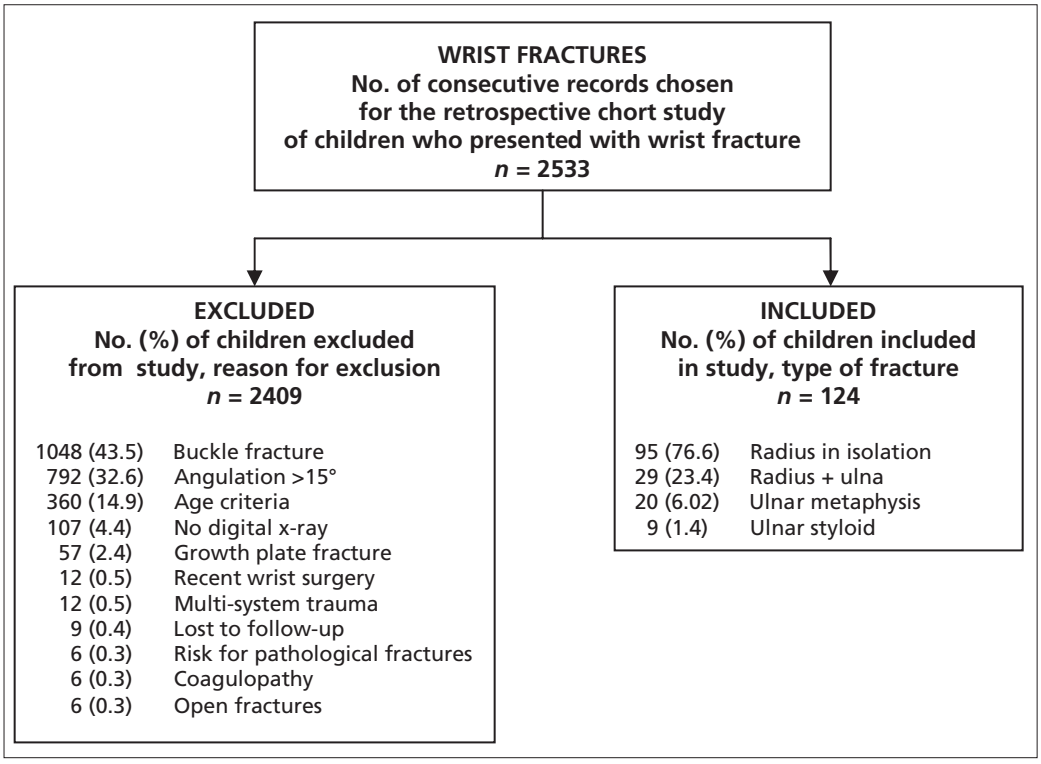


**Fig. 1. Disposition of the 2533 children who presented to the hospital's emergency department with wrist fractures**



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essary in the ED, it is seldom indicated during follow-up — despite early angular progression.

Our findings support the prior results of Do and colleagues,[3] who demonstrated that in a sample of 34 children with distal radius fractures with less than 15º angulation in any plane and less than 1 cm of shortening, fractures healed and remodelled to achieve a near perfect anatomic alignment. A study by Schranz and associates[11] described angulation progression in about 20% of distal third radius fractures (with initial angulation of ≤10° in the dorsal plane) and em-

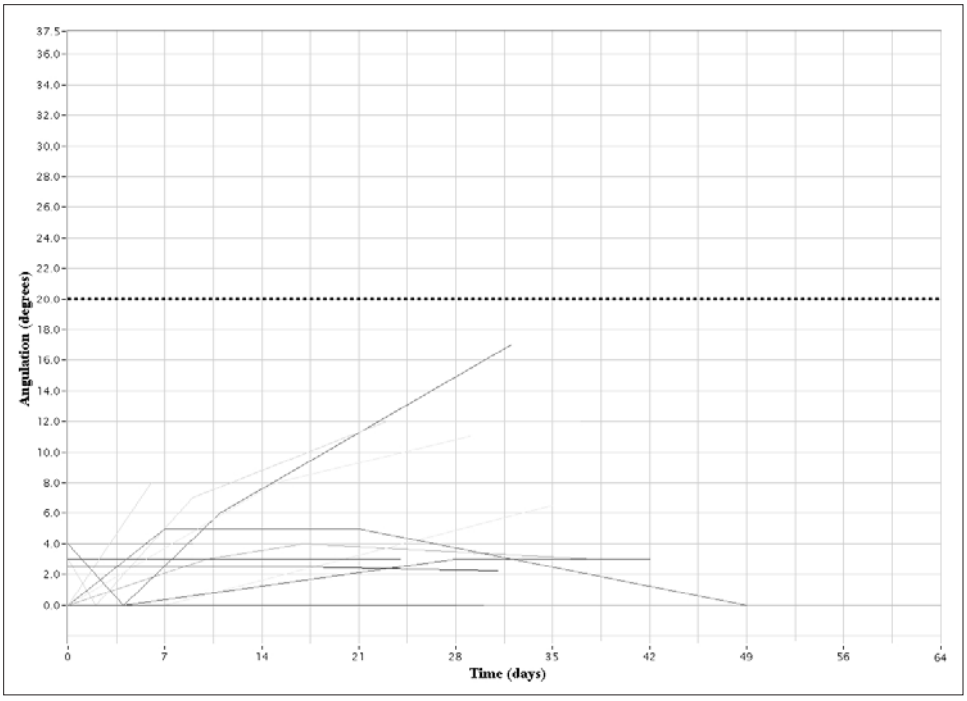


**Fig. 2a. Angulation changes in patients with initial angulation 0° to 4.0° (*n* = 40)**

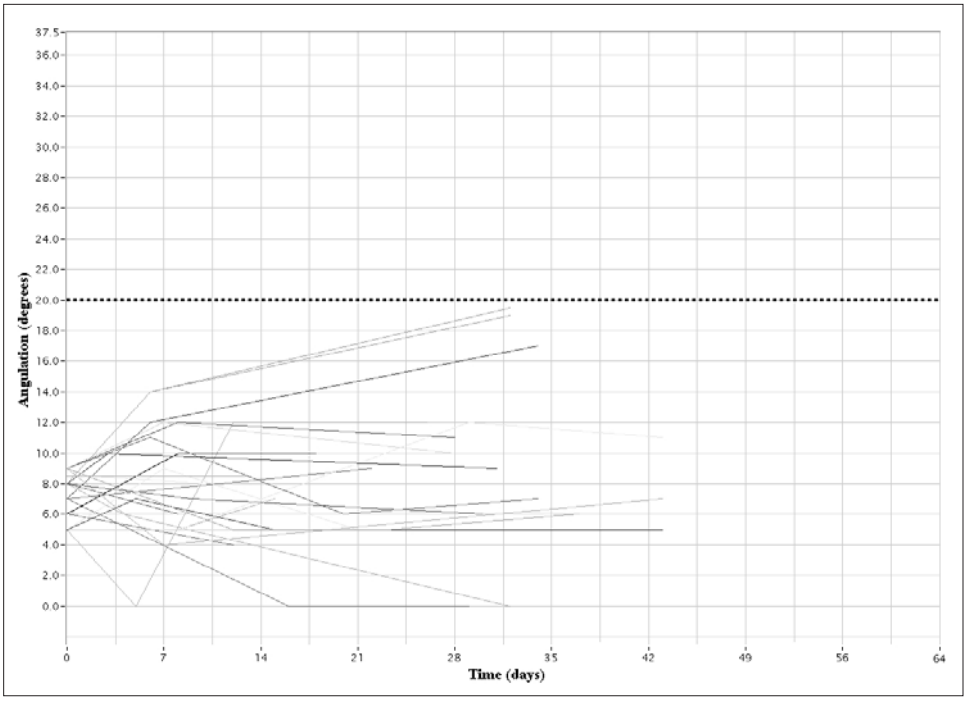


**Fig. 2b. Angulation changes in patients with initial angulation 5° to 9.9° (*n* = 27)**



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phasized that surgical manipulation in follow-up may be necessary. These authors did not quantify progression, stating only that displacement was defined as ≥5° without any clinical correlation. Nor did they report whether any of their study patients required surgical intervention during follow-up. The current study confirmed that distal metaphyseal radius fractures are unstable; however, if the initial angulation is ≤15º, it is highly unlikely to have any functional or cosmetic consequence for the patient, and therefore the requirement for surgical intervention would be rare.

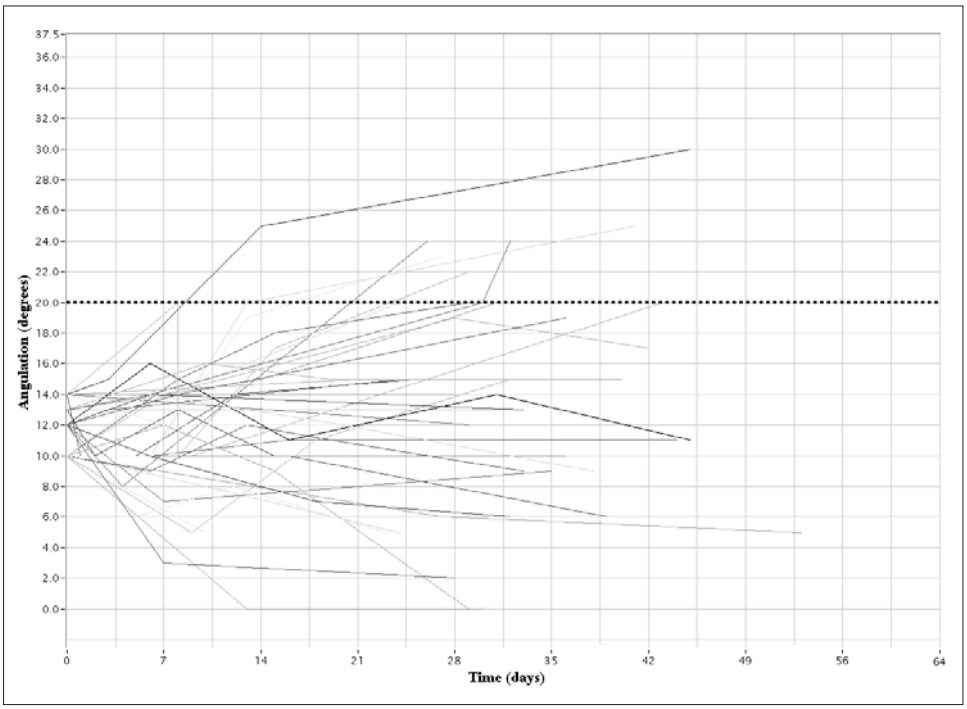


**Fig. 2c. Angulation changes in patients with initial angulation 10° to 15° (*n* = 57)**

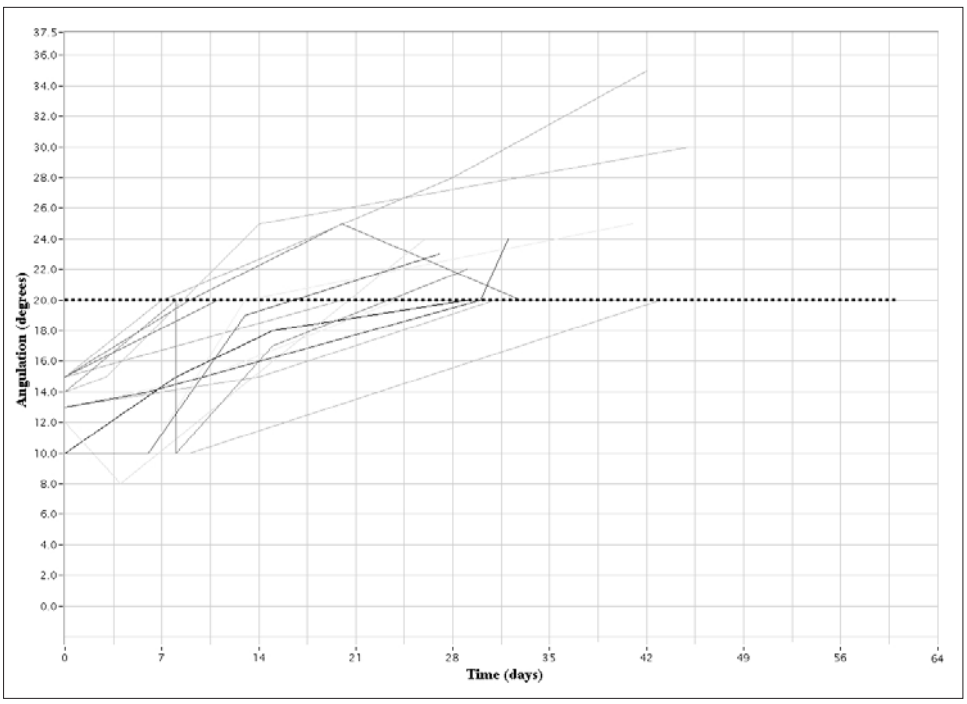


**Fig. 3. Patients who experienced angulation progression to ≥20° (*n* = 14)**



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### *Limitations*

This study has several limitations. A number of patients were lost to follow-up. In addition, the follow-up period was not sufficient to demonstrate if all fractures achieved complete radiographic remodelling. However, at the end of the 4–6-week period there was no clinical deformity of the wrist or functional impairment, and therefore it is unlikely that any residual angulation on x-ray would have affected management. Finally, despite the fact that standardized techniques were used to x-ray the wrist, rotation of the injured arm during radiography may have lead to factitious changes in angulation measurements in some cases.[12] However, because this measurement error is usually no more than 5º, it is unlikely to have affected our primary outcome.

## Conclusion

Minimally angulated distal metaphyseal radius (with or without ulna) fractures managed in plaster immobilization without reduction in the ED have a low likelihood of subsequently requiring surgical manipulation in follow-up.

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**Competing interests:** None declared.

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