

Displaced Distal Forearm Fractures in Children

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Abstract

Introduction: Distal forearm fractures are the most common cause for morbidity in otherwise healthy children. There is a wide variety of pediatric fractures. When sufficient force is applied, a complete 'adult-type' fracture may occur. By nature, these fractures are very unstable because of disruption of both cortices. Maintaining reduction is key for successful treatment. However, there is no consensus on how to maintain reduction in completely displaced distal forearm fractures in children. We evaluate success rate of closed reduction and cast immobilization.

Methods: Subjects were identified through emergency department administration in a single level II trauma center in the Netherlands. Subjects with displaced distal forearm fractures under the age of 14 years were included. All patients were treated with closed reduction and a three-point mold cast. Success is defined as preservation of reduction until consolidation.

Results: Treatment with closed reduction and cast immobilization was successful in 58.8% of the cases. In none of the subjects a re-intervention was indicated.

Conclusion: Most of the time the growth plate has enough remodeling potential. However, in completely displaced distal forearm fractures in children K-wire placement may be required to warrant reduction after initial reduction.

Level of evidence: Level IV, therapeutic.

Keywords: Forearm; Fractures; Displaced; Adult-type fracture; Children

Introduction

The incidence of pediatric fractures is 180 to 200 per 10,000/year [1,2]. The largest part of these fractures occurs in the forearm and this accounts for approximately 30% to 40% of pediatric fractures. Fractures in the distal third of the forearm account for 75% to 84% [3,4]. The most common trauma mechanism is a fall on an outstretched arm.

There is a wide variety of pediatric fracture types. This is a result of certain infant bone characteristics. A firm periosteal sleeve protects the underlying cortex, and, thereby, medullary bone. Furthermore, the bone in children is more pliable than in adults. Consequently, a fracture pattern related to above-mentioned qualities can occur without cortical separation: the buckle, or torus, fracture. Buckle fractures are considered the mildest form of fractures in which a force is exerted in longitudinal direction, causing bulging of the cortex in the transition zone between metaphyseal and diaphyseal bone [5]. Another common pediatric fracture is the ("infant-type") greenstick fracture, where the fracture occurs on one side, while the opposite cortex and periosteal sleeve remain intact. Two types of "infant-type" greenstick fractures are distinguished. First, the compression greenstick in which bending force is applied. As a result, the dorsal cortex (in case of apex volar) collapses, but the volar cortex remains intact or bows slightly. When more rapid force is applied, it is the volar cortex that ruptures

and the dorsal cortex remains intact or is only mildly deformed (bowing), the distraction fracture type [5,6].

However, when sufficient force is applied a complete "adult-type" fracture (fracture of both cortices) may occur in children. This is usually associated with displacement, but in rare cases length can be maintained. In case of displacement, the Bayonette apposition (there is no longer an end-to-end apposition) is the most common, mostly with displacement dorsally. In contrast to adult fractures, the periosteal sleeve on the side of displacement is often partially intact in children [5,6].

The choice of treatment is directly linked to the fracture type and its stability. In case of the buckle fracture, the periosteal sleeve and cortices remains completely intact, and is, thereby, by definition a stable fracture, and at no risk of displacement and will not require reduction and the pain is, therefore, only present for a couple of days (caused by the interperiosteal hematoma) [7,8]. Concerning the "infant-type" greenstick fractures, there is still no consensus concerning on how much angulation can be accepted and when reduction is mandatory. This depends on the growth potential of the bone (therefore the age of the child) and, thereby, the remodeling potentiality. In case of complete fractures sometimes the displacement can be accepted. However, as this can lead to esthetic, and more important, functional complaints; more often it is desirable to obtain reduction. These fractures are very unstable by nature, because of the disruption of both cortices and at least one periosteum. Therefore, the challenge is not to obtain but rather to maintain reduction.

Maintaining reduction can be achieved by different means. The most applied method is by cast immobilization, with the so called 'three-point' mold [9]. Despite pleas for long- or short arm casts and immobilization in different positions, no method has been proven perfect. For this reason, Kirschner wires can be inserted. However, the debate on the use of Kirschner wires is still ongoing and no official guideline can be created on this topic.

The aim of this study is to evaluate success rates of closed reduction and ('three-point' mold) cast immobilization in 'adult-type', displaced distal radial fractures in children.

Methods

Study population

Every patient under the age of 14 years, with skeletal immaturity, presenting at the emergency department with a complete fracture of the distal third radius was retrospectively included. Our hospital serves as a regional Level 2 trauma center and treats an increasing number of emergency department patients of around 35.000 patients. Fractures of the metaphysis and the distal third of the shaft were included, with or without fracture of the distal ulna. Incomplete or non-displaced fractures were excluded. Secondly, open fractures or associated nerve injuries were also excluded. Furthermore, patients with insufficient, radiological, follow-up were excluded for analysis.

Radiographs

Standard radiographs were made in every case at the moment of presentation at the emergency department, during initial reduction on the operating room, and during follow-up in the outpatient clinic department. This includes both anteroposterior and lateral views. All radiographs were evaluated by the main investigator, with consultation of a second when X-rays results could be ambiguous. The severity of displacement was measured.

Treatment

All patients were treated with closed reduction on the operating room. After confirmed reduction on peri-operative radiography, a below the elbow 'three-point' mold cast immobilization was applied. Follow-up consisted of consultation at 1, 4, and 6 weeks. Casts were removed based on X-ray and clinical view.

Endpoint

The endpoint of this study is success. Success is defined as the preservation of reduction after the initial closed reduction until consolidation is reached. Consolidation is evaluated by the treating physician. Failure is defined as redisplacement and is diagnosed by follow-up radiographs. Redisplacement was defined as loss of reduction of coronal angulation of $>10^\circ$, sagittal angulation $>30^\circ$, or redisplacement >0.5 shaft [10-12].

Results

Twenty-two patients with complete, displaced distal forearm fractures were identified. Four were excluded because stabilization was warranted by Kirschner wires. One was excluded because of insufficient follow-up. Seventeen patients were included for analysis. Fifty-three percent were male, median age of male subjects was 8.6

years (range 5.3 to 14.2). Female subjects had a median age of 8.1 years (range 5.6 to 10.5). In 15 cases both the radius and ulna were fractured, in the other patients it only concerned the radius. In all but one case displacement was dorsally. The left and right side were involved just as often. Median duration of cast immobilization was 33 days (range 13 to 47), with a median duration of follow-up of 37 days (range 13 to 55).

Success was achieved in 58.8% of the subjects. In the remaining 7 subjects (41.2%) follow-up X-ray showed angulation or partial displacement of the fracture. None of them required additional intervention or had disabling functional limitations. No follow-up radiographies were made after consolidation of the fracture; therefore, unfortunately, remodeling results could not be visualized.

Discussion

The aim of this study was to evaluate the success rate of closed reduction and cast immobilization in complete distal radial fractures. We found a success rate of 58.8% for closed reduction and cast immobilization only, in children with complete and displaced distal forearm fractures. In 7 subject's follow-up radiography showed re-displacement of the fracture. No re-intervention was indicated. No functional complaints were expressed during follow-up.

Our findings were in compliance with literature [10,13]. van Egmond et al. found a need for second reduction in patients with complete fractures in 42% of the patients primarily treated with closed reduction only, whereas none of the patients in the fixation group required secondary reduction [10]. Proctor et al. had a re-displacement rate of 20% to 73% in completely displaced fractures, depending on the success of initial reduction [13].

A randomized controlled trial by McLauchlan et al. (primary fixation with K-wires to reduction and cast only) found a significant difference in the need for a second intervention in the disadvantageous of the conservative group [14]. Colaris et al. confirmed these findings with a re-displacement rate of 8% versus 45%, respectively with and without K-wires [15]. In addition, they found a negative association with treatment with reduction and immobilization alone and pronation-supination limitations. Nevertheless, the conservative treatment group did show a significant less number of complications (23% versus 1.5%). Choi et al. reported a failure rate of 14.2% in patients in pinning was used to support reduction, and they demonstrated a complication rate of 7.1% related to the K-wires [16]. No premature growth plate closure was seen.

Mostafa et al. found satisfactory results in 87.5% cases of the displaced radius fractures treated with closed reduction and percutaneous K-wire fixation [17]. In case of residual radioulnar or dorsovolar angulations of $>15^\circ$ despite K-wire fixation, they found a positive association with decreased forearm rotation.

An important consideration in the decision making process whether or not to insert K-wires, is the difference between occurrence of re-displacement and the effect on functional outcome. There is great remodeling potential, because of the immature bone status in children and the proximity to the growth plate in distal forearm fractures. However, the outer limits of what is considered acceptable are arbitrary. In general, 20° to 25° of dorsovolar and 10° of radioulnar can remodel in younger patients [8,18,19]. Several studies are conducted on the risk factors for re-displacement following closed reduction; complete displacement was identified as a risk factor for the occurrence of re-displacement, though if anatomical reduction is

achieved the occurrence of re-displacement reduced significantly [20]. Also, poor quality of molding of the cast is seen as a risk factor, and a major influence, on re-displacement rates.

We recognize that there are some limitations to this study inherent to the character. First of all, due to the retrospective inclusion of the patients, treatment was not completely protocolled. Subtle differences in treatment are excised; this may be depending on physician, child, parent or type of fracture. Consequently, no direct conclusions on these outcome rates can be drawn. Yet, it does show that completely displaced forearm fractures have a high tendency to re-displacement when treated with cast immobilization only even with the use of 'three-point' mold cast. A second limitation concerns on the functional outcome of the re-displaced versus non-re-displaced fractures. Patient documentation does not mention functional limitations in any of the patients. However, no (standardized) functional test were executed, neither was there follow-up after remodeling.

Conclusion

Since completely displaced fractures of the distal radius is by definition an instable fracture with high re-displacement rates, K-wire fixation is an effective and safe way to offer additional stability. Nevertheless, if re-displacement is seen during follow-up and this displacement is within the acceptable limits (concerning the age of the child), let remodeling by nature occur and do not be tempted in surgical correction.

Message of the Authors

1) Most of the time the growth plate has enough potential for remodeling.

2) In case of reduction in the operating theatre, use a K-wire to lock the fracture for any possible re-displacement in cast immobilization.

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