Are frequent radiographs necessary in the management of closed forearm fractures in children?

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Abstract

Introduction A prospective pooled case series was used to assess the value of frequent radiographic examinations during treatment of closed forearm fractures in children from major university pediatric medical centers in Israel and China.

Methods The sample consisted of 202 consecutive children (mean age 7 years; range 3–12 years) with closed forearm fractures treated nonoperatively. Children with open, growth-plate fractures or fractures associated with dislocation of the nearby joint (i.e., Monteggia fractures) were excluded. In 28 children who had torus fractures, radiographic examination was performed at the time of cast removal, 3 weeks after the start of treatment. In 63 children who had stable fractures that did not require reduction (undisplaced or minimally displaced, complete or greenstick), radiographic examination was performed 1 week after the start of treatment and again at cast removal 4–6 weeks later. In the remaining 111 children with complete, displaced, or greenstick fractures (all with angulation

of more than 15°) who underwent closed reduction, an additional X-ray was taken 2 weeks after cast placement. All children (except those with torus fractures) were followed clinically, without further radiographic examination, for 3 months after cast removal.

Results Radiographs at cast removal showed good union in all stable fractures, indicating that additional X-rays on cast removal would have had no added value. In the children with unstable fractures, only 9 showed redisplacement with angulation of more than 15° on repeated X-rays during the first 2 weeks after cast placement. All 9 underwent successful re-reduction. On clinical evaluation 3 months after cast removal, all patients in the sample had full range of elbow and forearm motion. Repeated fracture did not occur in any of the patients.

Conclusions On the basis of these results, radiographs are recommended 2 weeks after cast placement for greenstick or complete fractures. At the time of cast removal, if clinical examination does not show signs of nonunion or malalignment, no radiographic examination is necessary.

Keywords Forearm · Fracture ·
Radiographic examination · Children · Follow-up

Study conducted at The Shanghai Children's Medical Center and Schneider Children's Medical Center of Israel.

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Introduction

Forearm fractures are the most common type of fracture in children. They usually heal within 6 weeks, with few complications. Redisplacement of unstable fractures is the most common complication, with an occurrence rate of 5–15% for shaft fractures and up to 30% for distal forearm fractures [1, 2]. Delayed healing or nonunion is rarely seen in healthy children with nonoperatively treated closed forearm fractures [3–5].

Several studies recommend repeated radiographic examinations at 1, 2, and even 3 weeks after initial fracture management for the early detection of in-cast displacement and, again, at the time of cast removal to assess healing [6–8]. However, the value of frequent radiographic follow-up and the indications for radiographic examination after cast removal have hardly been defined in scientific studies [7]. At the same time, concerns have been raised recently regarding the possible risks of using even low-dose radiation in children [9–11]. We hypothesized that reducing the number of radiographic examinations during the management of forearm fractures might safely spare children unnecessary radiation.

The aim of the present, prospective study was to assess the value of frequent radiographic examinations in the nonoperative treatment of closed forearm fractures in children.

Patients and methods

The study sample consisted of a total of 202 consecutive children with closed fractures of the ulna, radius, or both who were nonoperatively treated in two different pediatric medical centers, in Israel and China, between March 2002 and May 2003. In all cases, nonoperative treatment at admission was successful. Children who were treated operatively and children with open fractures, dislocated fractures, and growth plate fractures were excluded.

The patients were enrolled in the study prospectively and managed in accordance with the same standard departmental therapeutic protocol for forearm fractures in effect at that time. The specific type of treatment performed was determined by the attending resident or consultant. The children were followed by the authors, all of whom were senior physicians with at least 3 years of experience in pediatric orthopedic surgery (maximum, 22 years' experience).

The 202 children included 149 boys and 53 girls of average age 7 years (range, 3–12 years). Of the fractures, 94 were on the right side and 108 on the left; 62 involved the radius, 14 the ulna, and 126 both. At presentation, antero-posterior and lateral radiographs were performed in all cases. A total of 91 children were found to have stable or relatively stable fractures (undisplaced or minimally displaced fractures with angulation of less than 10° that did not require reduction). Of these, 28 children presented with torus fractures of the distal radius and were treated with a below-elbow cast for 3 weeks. They underwent repeated radiography at the time of cast removal, according to our protocol; further follow-up was not considered necessary. The other 63 children had undisplaced or minimally displaced fractures with angulation of less than 10°, which did

not require reduction according to our protocol and the decision of the attending physician. This group included 32 children with greenstick or complete distal-end forearm fractures who were treated with a below-elbow cast, and 31 children with midshaft fractures who were treated with an above-elbow cast. The attending resident decided which type of plaster cast was used for immobilization, in accordance with our protocol. In all 63 children, radiographs were performed immediately after cast application, 1 week later, and at cast removal after 4–6 weeks, depending on the patient's age and type of fracture. Clinical examination only, without X-rays, was repeated after 3 months to assess elbow and forearm function and range of movement.

The remaining 111 children in the study sample presented with unstable fractures (completely displaced fracture or fracture with angulation of more than 10° that required reduction). They all presented with a greenstick fracture with angulation of more than 15° or complete displacement and were treated with closed reduction and immobilization in an above-elbow cast. The closed reduction was performed in the emergency department under local anesthesia for patients with a distal forearm fracture ($n = 55$) or in the operating room under general anesthesia for patients with a forearm shaft fracture ($n = 56$). Radiographs in these patients were made four times during fracture management: after cast placement, at 1 and 2 weeks after placement, and again at cast removal after 4–6 weeks, depending on the patient's age and type of fracture. All children (except those with torus fractures) were also re-evaluated clinically 3 months after cast removal, without X-rays, to assess the function and range of movement of the elbow and forearm.

Results

All 28 children with torus fractures treated by 3 weeks in a plaster cast showed good union on the radiographs performed at cast removal. No further follow-up was performed.

In the 63 children with undisplaced or minimally displaced fractures and an angulation of less than 10°, radiographs performed 1 week after cast placement and at cast removal 4–6 weeks later showed no further displacement and good union. On clinical follow-up 3 months later, there was full range of pain-free motion in all cases.

Of the 111 children with greenstick fractures and an angulation of more than 15° or complete displacement which required reduction, 9 (3 with midshaft fracture and 6 with metaphyseal fracture) showed re-angulation of more than 15° on radiographs performed 1 or 2 weeks (average 11 days) after cast placement. No fracture redisplaced

without angulation to warrant further treatment. In all 9, re-reduction was performed under general anesthesia in the operating room within 2 weeks, and the above-elbow plaster cast was removed after 6 weeks. There were no complications, and radiographic examination showed good union at cast removal, without displacement or shortening or angulation of more than 10° . In the other 102 children, the initial reduction was successful, and there was no change between the 2-week and subsequent radiographs. For the whole subgroup, clinical follow-up at 3 months after cast removal showed a full range of motion without pain and no refracture.

Discussion

This study was conducted to determine whether fewer radiographs than the current norm can be safely performed in children with forearm fractures, without compromising outcome. We found that in all the children with torus fractures, cast immobilization was successful, with no displacement and no complications, so that the inclusion of additional radiographs during management or after cast removal would have had no added benefit. These results support previous studies indicating that forearm torus fractures in children may be safely treated using a wrist splint that can be removed at home by the parents [12–14].

Furthermore, we noted no in-cast displacement in any of the children with undisplaced, minimally displaced, or angulated fractures of less than 10° . Although this finding is in agreement with some studies [8], others reported displacement of initially undisplaced distal forearm fractures [15]. Therefore, given that these fractures are relatively unstable, and despite the fact that our study shows no displacement of this type of fracture in case, we recommend radiographic follow-up 2 weeks after the start of treatment. Our study and others show that full healing generally occurs within 4–6 weeks [16, 17]. In our opinion, if clinical examination after cast removal shows no signs of malunion—clinical appearance of deformity of the fractured forearm compared with the contralateral forearm—radiographic examination is unnecessary.

Previous studies have noted that fractures requiring reduction tend to redisplace in the cast [2, 8], and most authors recommend radiographic follow-up for reduced fractures as frequently as weekly for 2 or 4 weeks [6, 8]. However, we noted a relatively low rate of in-cast redisplacement after nonoperative reduction (9 of 111 patients). This finding, together with reports that fracture redisplacements usually occur within 2 weeks after initial reduction [16]—which was also true for our patients—may indicate that radiographic follow-up at 2 weeks after initial reduction will detect almost all fracture redisplacements,

when remanipulation can still be performed. Therefore, we suggest that the radiographic examinations at 1 week and again at 3 weeks during treatment are not necessary in most cases.

Our protocol to reduce redisplaced fractures with angulation of more than 10° in all forearm fractures is controversial. Several authors, however, accept this amount of angulation in distal-end fractures in young children, owing to their remodeling potential [18].

Delay of union or nonunion is rare in healthy children younger than 12 years in whom fractures are treated non-operatively [3, 4]. This small risk, in our opinion, does not justify the routine use of radiography at the time of cast removal in otherwise healthy children with a closed fracture and no clinical signs of nonunion (pain at the fracture site aggravated by stress [3, 19]). The causes of refracture that may occur in the first year after cast removal and the methods of its prevention are controversial [20, 21]. The 3-month follow-up in this study is too short to answer this question.

The bony tissues of children are proliferative compared with those in adults and, therefore, more susceptible to the harmful effects of ionizing radiation [9, 11]. In children with forearm fractures, repeated radiographic examinations are recommended during cast immobilization, for early detection of fracture displacement, and at cast removal, to assess fracture consolidation [2, 6, 8]. However, this exposes the children to antero-posterior and lateral radiation at least 5–6 times within a 4- to 6-week period, in addition to the imaging intensifier radiation at fracture reduction. Although there are no studies of the possible relationship of this amount of exposure and malignancy, a recent report in *The National Academies* [11] claimed that “There is no threshold of exposure below which low levels of ionizing radiation can be demonstrated to be harmless or beneficial. The health risks—particularly the development of solid cancers in organs—rise proportionally with exposure. At low doses of radiation, the risk of inducing solid cancers is very small.” The amount of radiation involved in antero-posterior and lateral X-ray of the forearm is about 0.02 gray (Gy). Although radiation dose for a single procedure might be low, repeated examinations over time could result in relatively high cumulative doses. Hubner et al. [22], in an attempt to reduce the exposure of children to radiographic radiation, found that ultrasound may serve as a satisfactory alternative for certain fractures.

Forearm shaft fractures differ from distal-end fractures in terms of anatomy, mechanism, indication for management, and method of management. However, we included both types in this study because their recommended radiographic follow-up regimens are similar [2, 8].

In contrast to recommendations for repeated radiographs at 1, 2, and 3 weeks and at the time of cast removal [6–8],

the results of the present study show that the performance of fewer X-rays at appropriate times during the management of forearm fractures will yield reliable results with no loss in quality of care.

Our study is limited by the fact that we did not directly test the protocol we suggest here. However, its use prior to the present findings would have been unethical. Furthermore, it should be borne in mind that selected fractures, such as bayonet apposition in adolescents, may be managed in a cast without fixation and therefore may require more radiographs over 3–4 weeks.

In conclusion, the application of our recommendations will spare children unnecessary radiation during fracture treatment without decreasing the quality of care. Reducing the number of clinical and radiographic examinations will decrease the cost of treatment.

References

- Herring JA (2002) Tachdjian's pediatric orthopaedics. 3rd edn. Saunders, Philadelphia, p 2227
- Waters PM (2001) Distal radius and ulna fractures. In: Beaty JH, Kasser JR (eds) Rockwood & Wilkins' fractures in children, 5th edn. Lippincott Williams & Williams, Philadelphia, p 417
- Adamczyk MK, Riley PM (2005) Delayed union and nonunion following closed treatment of diaphyseal pediatric forearm fractures. *J Pediatr Orthop* 25(1):51–55
- Arslan H, Subasy M, Kesemenli C (2002) Occurrence and treatment of nonunion in long bone fractures in children. *Arch Orthop Trauma Surg* 122:494–498
- Price CT, Scott DS, Kurzner ME, Flynn JC (1990) Malunion of forearm fractures in children. *J Pediatr Orthop* 10(6):705–712
- Bohm ER, Bubbar V, Yong-Hing K, Dzus A (2006) Above and below-the-elbow plaster casts for distal forearm fractures in children. A randomized controlled trial. *J Bone Joint Surg Am* 88:1–8
- Green JS, Williams SC, Finlay D, Harper WM (1998) Distal forearm fractures in children: the role of radiographs during follow-up. *Injury* 29(4):309–312
- Price CT, Mencia GA (2001) Injuries to the shafts of the radius and ulna. In: Beaty JH, Kasser JR (eds) Rockwood and Wilkins' fractures in children, 5th edn. Lippincott Williams & Williams, Philadelphia, pp 455–460
- Don S (2004) Radiosensitivity of children: potential for overexposure in CR and DR and magnitude of doses in ordinary radiographic examinations. *Pediatr Radiol* 34(Suppl 3):S167–S172
- Kleinerman RA (2006) Cancer risks following diagnostic and therapeutic radiation exposure in children. *Pediatr Radiol* 36(Suppl 2):121–125
- Low levels of ionizing radiation may cause harm (2005) The National Academies. <http://www.nasonline.org>
- Davidson JS, Brown DJ, Barnes SN, Bruce CE (2001) Simple treatment for torus fractures of the distal radius. *J Bone Joint Surg Br* 83:1173–1175
- Plint AC, Perry JJ, Correll R, Gaboury I, Lawton L (2006) A randomized, controlled trial of removable splinting versus casting for wrist buckle fractures in children. *Pediatrics* 117:691–697
- van Bosse HJ, Patel RJ, Thacker M, Sala DA (2005) Minimalistic approach to treating wrist torus fractures. *J Pediatr Orthop* 25:495–500
- Schranz PJ, Fagg PS (1992) Undisplaced fractures of the distal third of the radius in children: an innocent fracture? *Injury* 23(3):165–167
- Haddad FS, Williams RL (1995) Forearm fractures in children: avoiding redisplacement. *Injury* 26(10):691–692
- Schwarz N, Pienaar S, Schwarz AF, Jelen M, Styhler W, Mayr J (1996) Refracture of the forearm in children. *J Bone Joint Surg Br* 78(5):740–744
- Ploegmakers JJ, Verheyen CC (2006) Acceptance of angulation in the nonoperative treatment of paediatric forearm fractures. *J Pediatr Orthop B* 15(6):428–432
- Babhulkar S, Pande K, Babhulkar S (2005) Nonunion of the diaphysis of long bones. *Clinic Orthop Relat Res* 431:50–56
- Park HW, Yang IH, Joo SY, Park KB, Kim HW (2007) Refractures of the upper extremity in children. *Yonsei Med J* 48:255–260
- Bould M, Bannister GC (1999) Refractures of the radius and ulna in children. *Injury* 30:583–586
- Hubner U, Schlicht W, Outzen S, Barthel M, Halsband H (2000) Ultrasound in the diagnosis of fractures in children. *J Bone Joint Surg Br* 82(8):1170–1173