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Influence of Clinical Information on the Detection of Wrist Fractures in Children

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Ehara, S. and Katsuragawa, S. *Influence of Clinical Information on the Detection of Wrist Fractures in Children.* Tohoku J. Exp. Med., 1999, **189** (2), 147-153 —— The purpose of this investigation is to assess the importance of clinical information for the detection of non-displaced wrist fractures in children. Twenty non-displaced fractures of the distal radius in children younger than 15 years of age and twenty age-matched controls were evaluated by five blinded observers before and after giving clinical data, and a receiver operating characteristic (ROC) analysis using a continuous rating scale with a line-marking method was performed. The detection of the fractures was significantly improved with clinical information, and the main reason for this was an increase in true positive fraction. Availability of adequate clinical data should be emphasized for interpreting radiography. ——— radiography; incomplete fracture; wrist; ROC analysis

Fractures of the wrist are a common injury in children. Incomplete fractures, in particular, such as torus and greenstick fractures with subtle findings, frequently occur in children (Fig. 1). Radiologic features are well described in the textbooks, but the detection of fractures in the acute phase is still a frequently encountered difficulty in our daily clinical practice (Rogers 1992; Rockwood et al. 1996). When radiological findings are equivocal, clinical information, including point of tenderness and soft tissue swelling, is important to make a decision on whether or not it is better to treat the injury as a fracture. However, it is often not an option if radiography is evaluated after the patient's discharge and if the necessary information is not well described in the medical record. The impact of clinical information on fracture detection is well recognized clinically, but scientific research on the perception of subtle fractures is scarce in this region. The purpose of this investigation is to assess the importance of clinical information for the detection of non-displaced wrist fractures in children for better

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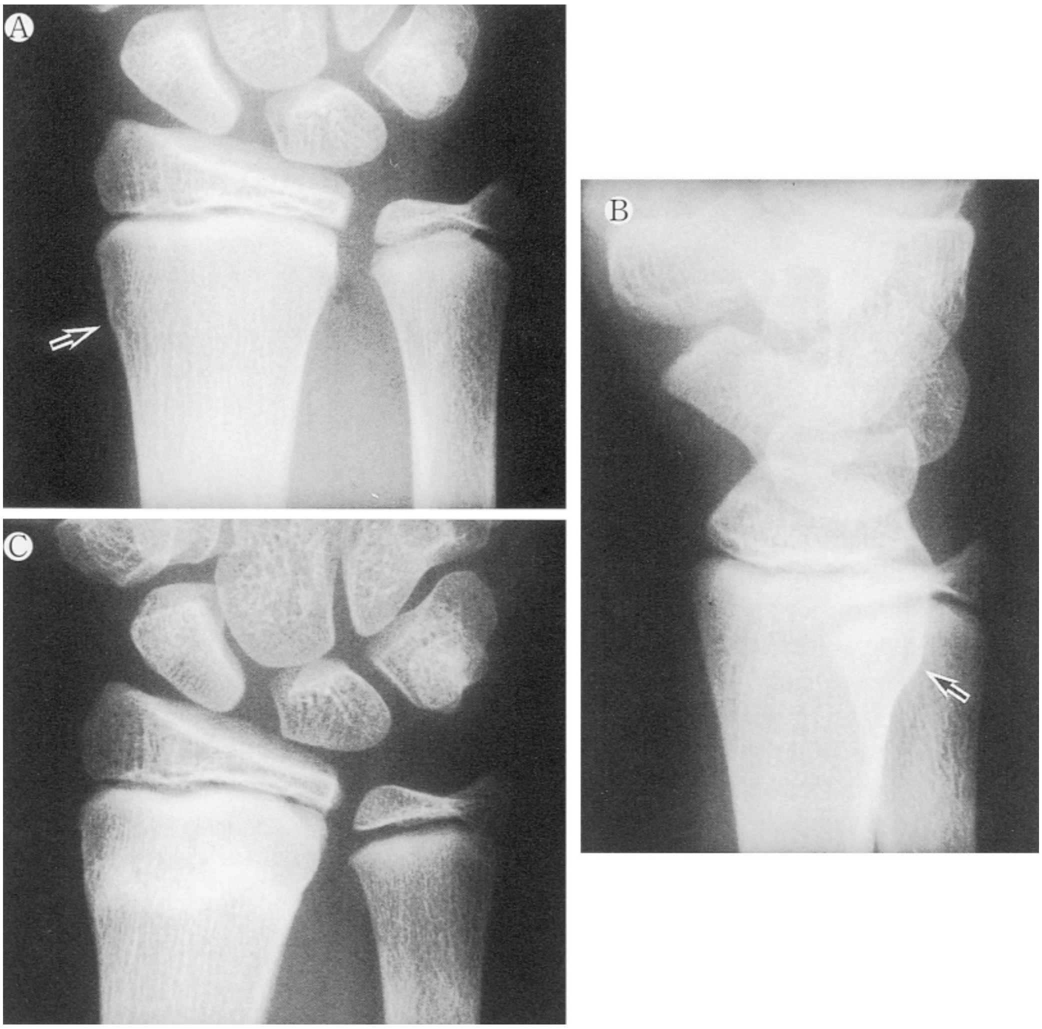

Fig. 1. Torus fracture of the distal radius (11-year-old girl). A: Postero anterior (PA) view, B: lateral view, C: PA view obtained 3 weeks after trauma. PA and lateral views show subtle protrusion of the radial and posterior cortex, representing torus fracture (arrow). PA view obtained 3 weeks later reveals fracture healing with a band of sclerosis.

management of subtle fractures as well as for improvement of education of physicians in training.

Materials and Methods

Radiographic examinations of twenty non-displaced fractures of the distal radius in children younger than 15 years of age were accumulated during a two-year period in our hospital. These fractures were treated clinically as fractures and followed the process of healing. Non-displaced complete fractures with an evident fracture line, displaced fractures, comminuted fractures, and pathologic fractures were excluded. Radiography of twenty age-matched controls was collected during a 10 month period.

Three radiologists and two orthopedic surgeons participated in this study as observers. The three radiologists were general diagnostic radiologists with 8–12

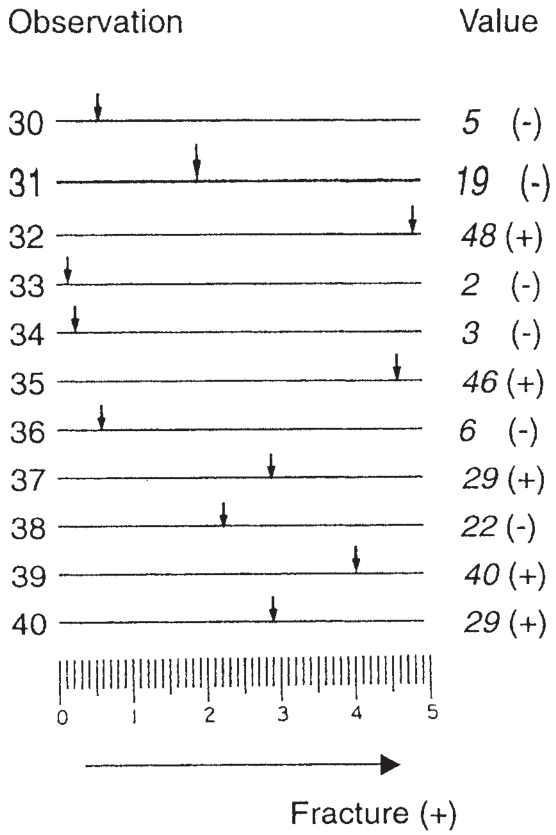

Fig. 2. A worksheet for continuous rating scale method. Each observer marks the level of confidence in regard to the presence or absence on a 5 cm bar.

years of experience and the two orthopedic surgeons had 5 and 10 years of experience, respectively.

Twenty fracture cases and 20 control cases were mixed in a random fashion and the possibility of fracture was estimated. Because of homogeneity of the patient group and similar type of fracture, forty studies in each reading session by five observers (200 observations) were used in this analysis. A continuous rating scale with a line-marking method was used to represent each observer's confidence level regarding the presence or absence of a fracture as described by Metz et al. (1998) (Fig. 2). By this method, the observer marked his or her confidence level on a 5 cm bar. The right and left ends of the bar corresponded to the definite presence and definite absence, respectively, of a fracture.

As the first part of this study, intraobserver variation was estimated in two observers (radiologists). Two reading sessions without any clinical information were held one month apart. The interpreters were only instructed that the indication of the study was "trauma." The cases presented for interpretation in these two sessions were the same, but in different order. For analysis, Pearson's correlation coefficient was used.

As the second part, influence of clinical information on fracture detection was assessed. The first reading session was held with no clinical information. The observers were only instructed that the films were obtained for the evaluation of trauma. The ages of the patients were not notified, although they were easily estimated by skeletal maturation. The second reading session was held two months later. In all the fracture cases and in half of the control cases, the point of tenderness was notified to the readers. This simple model has relatively high positive rate than most actual clinical settings, but it is considered to help estimate contribution of clinical information in a reproducible manner.

For an ROC analysis, a continuous rating scale and the curve fitting program (LABROC4) was used to assess the influence of clinical information for fracture detection (Rockette et al. 1992; Metz et al. 1998).

Results

Reproducability of the grading was in the acceptable level, and correlation coefficients in the two observers ($r=0.86, 0.85$) were significantly high. The detection of the fractures was significantly improved with clinical information ($p<0.02$), and the main reasons for this was an increase in true positive fraction based on superior displacement of the ROC curve (Fig. 3). In the negative (control) cases, the rating of fracture possibility also increased in some observers representing increased false positive fraction (Table 1). No significant differences were noted between the radiologists and the orthopedic surgeons, or due to duration of clinical experience, but it was difficult to draw conclusions based on this small number of observers. Subtlety of the fracture did influence detection as expected. Degree of displacement and deformity may correlate with the difficulty of fracture detection, but quantitative analysis was difficult in the subtle fractures we dealt with (Fig. 4). Observers stated that irregular epiphyseal plates

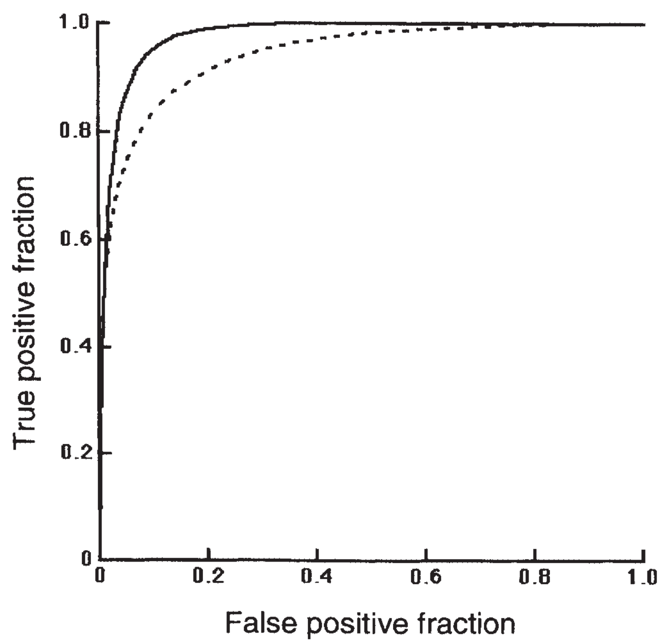

Fig. 3. ROC curves on the detection of fractures without and with clinical data. The improvement in fracture detection is significant ($p<0.02$). ——, with clinical data (Az=0.972); ------, without clinical data (Az=0.928).

TABLE 1. *Number of cases with change in the rating scale before and after providing the clinical data*

Fracture Rating	Positive		Negative	
	Increased	Decreased	Increased	Decreased
Observer A	2	1	2	6
Observer B	2	0	7	3
Observer C	2	1	4	1
Observer D	6	0	0	3
Observer E	3	0	1	1

The change in the scale of 10 (mm) or more is considered significant and included in this table.

Fig. 4. Subtle fracture of the distal radius, the type most frequently missed without clinical data in a 14-year-old boy. Bowing of the cortex and trabeculae at the radial aspect of the distal radial metaphysis is noted, although subtle (arrow).

added difficulty to the diagnosis of relatively older subjects, but it was not statistically proved in a relatively small number of cases with mature epiphyses and open epiphyseal plates.

DISCUSSION

Influence of clinical data on the detection of lesions is well known and easily understood in our daily clinical experience. However, the reports on the actual influence of clinical information in statistical manner are scarce. In many situations, radiologists or orthopedic surgeons may have to review radiography with only limited clinical information particularly in busy emergency departments, and this is the main cause of difficulty in diagnosing acute trauma cases.

Particularly in children, many fractures are incomplete and the findings are often a minimal deformity or a minimal disruption of one side of the cortex. Although the wrist is a common site of such subtle fractures, radiologists, as well as orthopedic surgeons, often miss such subtle fractures. Most of such fractures are stable and they heal with no sequellae, but occasionally the deformity may necessitate corrective osteotomy particularly when injury to growth plate is associated. We also hope that this methodology using such a simple model may extend into clinically more significant injuries, such as physeal injury and intraarticular fractures including scaphoid fractures.

Errors in diagnosis have become important in the medicolegal sense, and they are now the subjects of scientific investigation. Perceptual and cognitive errors, but not poor technical images, constitute a major component of errors (Renfrew et al. 1992). There are also other factors that may influence the detection of abnormal findings. Berbaum et al. (1988) investigated effects of knowledge of the clinical information on the fracture detection in various locations. They used mixed cases of fractures of different sites and concluded that information on the localization of abnormalities prompted the diagnosis and that the effect of the improvement was largely in the increased number of true positive cases. We followed their methodology and combined with continuous-scale rating ROC analysis. The pattern of improvement in our series was similar to their results. This type of perception study, although not widely performed, constitutes an important part in the investigation of the nature of errors in diagnosis.

There are several limitations in our investigation. First, the setting of interpretation of radiography is artificial. The preliminary assessment of fracture rates in the radiography of traumatized wrist in children is 10–15% in our daily practice, but it varies in different clinical settings. The mixture of twenty positive cases and twenty control cases is, at least, adequate to prove the degree of influence by relatively short reading sessions (approximately 30 minutes in most observers). Our simple model is exaggerated with higher positive rate, but we consider that it is useful for assessing the influence in this relatively small number of cases. Second, the ratio of positive physical finding is also artificial. Point tenderness is a sensitive sign for fracture, but the specificity is generally low. Most patients referred for radiography of traumatized wrists have pain and tenderness of various degrees and extent. The validity of this setting is difficult to estimate since the specificity and the sensitivity vary a great deal among the treating physicians.

For readers with adequate clinical experience, detection of most fractures is not difficult, but 100% accuracy is still difficult to accomplish. The availability of adequate clinical data should be emphasized for interpreting radiography of suspected fractures. The information on the tendency of missing fractures should also contribute to the improvement of education of physicians in training.

Acknowledgments

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