Acceptance of angulation in the non-operative treatment of paediatric forearm fractures

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Forearm fractures are the most common injury in paediatric traumatology. The unique properties of the juvenile skeleton make it possible to cope well with traumatic deformities such as angulation, apposition and displacement. While we make use of these properties, the exact mechanism and degree of healing remains obscure. Different types of forearm fractures require specific treatment options, each with its limitations. A meta-analysis of recent literature was carried out, and together with the opinions of 18 international experts an effort was made to provide insight into the limits of acceptance of angular deformation in the non-operative treatment of paediatric forearm fractures. With this information we constructed graphs (age versus angulation) for each of the eight types of paediatric forearm fractures. In the absence of proper trials, it is our opinion that the presented Isala graphs can provide useful support in the decision-making process of acceptance of angular deformities in paediatric forearm fractures. *J Pediatr Orthop B* 15:428–432 © 2006 Lippincott Williams & Wilkins.

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Introduction

The paediatric skeleton contains unique properties that make injury treatment different from the adult skeleton. The thicker periosteal sleeve in the immature skeleton has a distinct effect on injury impact and healing. Fractures, especially in long bones that are growing, will correct and remodel in time. The remodelling capacity depends on the proximity of fracture to the physis; favourable results appear if the fracture is close to the physis. Hence, certain fracture alignments in children can be acceptable that would otherwise not be the case for adults. What the acceptable limits of contact and angulation should be in the treatment of paediatric forearm injuries remains unclear. To gain more knowledge into the degree to which an angular deformity could be acceptable for conservative treatment, we reviewed the literature and contacted experts for their opinion. Rotational translation and position or length of immobilization are beyond the scope of this publication.

Methods

We searched the Cochrane Library [1] in January 2006 and did not come across reviews on paediatric forearm injuries. A Medline search was conducted and we searched for forearm trauma in childhood with related fractures and deformities. Search keys used were plastic deformation child, buckle fracture, torus fracture, Greenstick fracture, metaphyseal fracture, Colles fracture child, Smith fracture child, forearm fracture child, antebrachii fracture child, Galeazzi fracture child, Monteggia fracture child, proximal radial and epiphysiolysis. Papers in languages other than English, German, French and Spanish were excluded from this review, as were single case reports, adult fractures and veterinary papers. This left 218 original articles that were obtained and analysed; 75 met our predefined methodological criteria for paediatric forearm fractures, which advised on angular acceptance. These criteria included the non-operative treatment of paediatric forearm fractures with a minimum patient population of three, follow-up of at least 6 months and clear advice for age-dependent angular acceptance.

Using identical search terms, the Internet was searched for (non-peer-reviewed) recommendations regarding the conservative treatment of paediatric forearm fractures.

The same proposals for treatment were collected from medical textbooks managing orthopaedics, trauma, paediatrics or a combination of these topics, finally resulting in five textbooks [2–6].

Thirty experts, based on published literature and expert supposition as selected by both authors after advice from L. von Laer, were asked to fill in a survey containing an example without subject heading and eight blank graphs for the following fracture patterns/types: plastic deformation; distal radial physis, torus, Greenstick; distal radius (complete); both bone forearm distal 1/3 and middle 1/3; and radial neck fracture. Age (years) on the *x*-axis and angulation (degrees) on the *y*-axis were plotted. Experts were asked to mark the different fracture graphs for degrees of angulation at each year (0–15), in order to indicate their limits of acceptance for both sexes of angular deformities in the conservative treatment of paediatric forearm fractures.

Literature review of forearm fracture patterns together with the experts' opinions result in the construction of graphs representing the limits of acceptance of angular deformities of these fractures.

Results

The data collected from peer-reviewed journals and textbooks for each fracture type were pooled, as were the results from the survey among experts. Data collected from Internet web sites were excluded. The Internet search was not satisfactory in number and especially in quality of hits. Most references on the web sites referred to conventional literature, which was already covered by the collected literature and textbooks.

The graphs for each investigated fracture are represented in Fig. 1a–h for both literature and expert opinions. Age (years) was plotted against the limit of acceptable angular deformity (degrees) with one standard deviation. We organized both bone forearm fractures in two separated graphs according to proximity of fracture, with similar literature data but different experts' opinion. This was done because generally the literature does not make a differentiation between localization of this diaphyseal fracture. A wide variation among fracture patterns/types was found in the totality of references from journals and textbooks used to construct each graph.

- Plastic deformation: five references [7–11].
- Distal radial physis: 11 references [2,6,12–20].
- Torus: two references [21,22].
- Greenstick: 12 references [3,4,20,23–31].
- Distal radius (complete): 15 references [2,3,6,14,24, 27,28,32–39].
- Both bone forearm (distal and middle): 27 references [2,3,5,21,25,28,32,35,40–58].
- Radial neck: 28 references [2–4,6,17,18,59–80].

We did not include Monteggia's and Galeazzi's fractures, which are obviously also types of paediatric underarm fractures, because strictly speaking these fractures are beyond the scope of this publication: neither fracture has angulation as its major deformity characteristic. This is reflected by the scarce literature on acceptable angular deformation for these two fracture types.

Discussion

The decision as to whether to accept, reduce or operate traumatic paediatric forearm fractures is rarely based on objective empirical criteria. In daily practice, experience and gut feeling are the essential parameters on which physicians rely. The problem in evaluating treatment options in traumatology is often the absence of prospective randomized-based literature with evidence-based treatment options. Knowledge on the treatment of paediatric forearm fractures is based on scarce retrospective research, expert experience and case reports. Regarding this review, only six prospective non-randomized studies were recorded with rather small numbers of fractures (3–68) [9,26,28,36,65,81].

There exists a general tendency in the literature to treat angular deformed fractures in children conservatively, though in everyday clinical practice problems arise in accepting the more severe angulations. Although these deformities in paediatric fractures are renowned for their tendency for correction in time, they are considered by many as unpredictable and there is no consensus of the degree to which a deformity is acceptable. Furthermore, initially deformations are clearly noticeable and easily rejected on aesthetic grounds, resulting in over-treatment with a seemingly acceptable complication rate and good patient satisfaction. More knowledge of the limits of tolerance of specific paediatric fractures possibly narrows the indication for reduction or operative treatment.

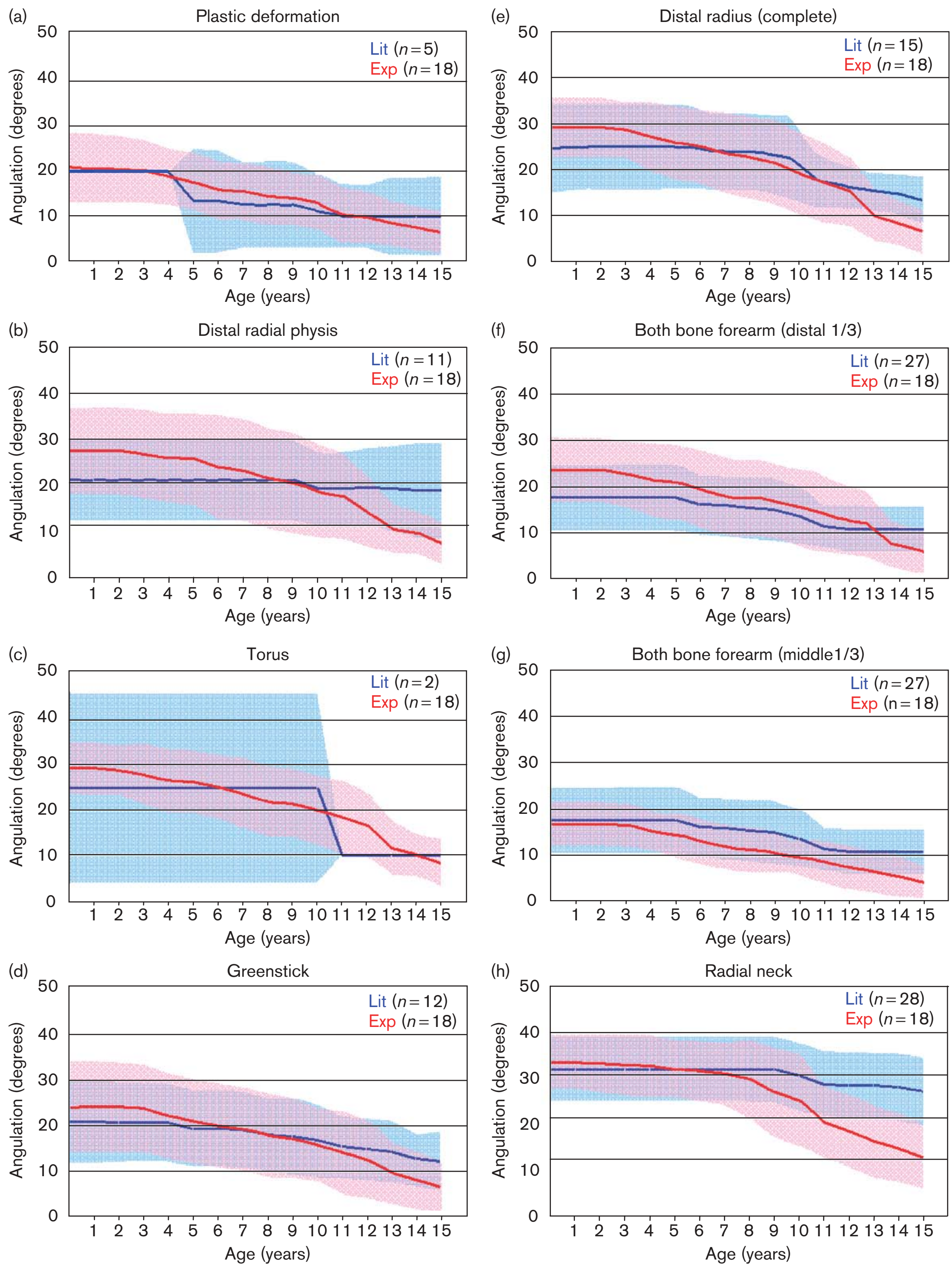
Our analysis started with a literature search and graphic conversion of the results for each fracture type. We are aware of the fact that the Achilles' heel of this study is the methodology applied to include data from the literature. As these data are heterogeneous and unbalanced, we additionally requested the opinion of experts.

We investigated literature on children in the age category 0–15 years; in the 15th year skeletal age is maturing and in most children the physes are closing. After this age, bone response to external forces is quite similar to that of adults. We are aware of the fact that girls remain 2 years ahead of boys in maturation, particularly above the age of 10 years.

We did not construct separate graphs per sex because the literature rarely makes this distinction. For the same reason, the items 'torus' and 'Greenstick' are not further specified for anatomical position, although the anatomical location is commonly the distal radius. All graphs are assembled for the ages of 0–15 years. As an illustration, it is obvious that for plastic deformation and torus only the younger ages are of significance, and vice versa for both bone forearm fractures.

The degree of rotation or translation was not taken into account in the graphs. One should definitely take into consideration that in every specific fracture these factors play an important role in the decision of acceptance of the deformity.

Fig. 1



Graphs showing age (years) plotted against angulation (degrees): (a) plastic deformation, (b) distal radial physis, (c) torus, (d) Greenstick, (e) distal radius (complete), (f) both bone forearms (distal 1/3), (g) both bone forearms (middle 1/3) and (h) radial neck. The lines represent the limit of acceptance of deformity for each specific fracture: pooled data from literature (blue line) and experts' opinion (red line) with one standard deviation. Between brackets are the number of references from literature (Lit) and the number of experts (Exp).

Another matter is that the purpose of arbitrarily including one standard deviation in each graph is not to mark the boundaries between which the turning point for acceptance is located, but rather to give an impression of the range of opinions in the literature and experts. Consequently, we chose not to conduct a statistical analysis on possible differences between data derived from the literature and those from the experts because of differences in methodology and distribution of data. It is therefore evident that the data are neither intended for nor suitable to be converted into dogmas in the treatment of these fractures.

Conclusion

Juvenile reaction to trauma seems unpredictable, with a tolerance where the paediatric skeleton tends to grow, adapt to biomechanical forces and develop on one side and premature physeal closure, synostosis formation and necrosis on the other.

Given the lack of proper trials, it is our opinion that the presented Isala graphs can provide useful support in the decision-making process of acceptance of angular deformities in paediatric forearm fractures.

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