



Management of acute paediatric fractures treated surgically in the UK: a cross-sectional study

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ABSTRACT

Introduction The epidemiology of acute paediatric orthopaedic trauma managed surgically across the NHS is poorly described. Compliance against national standards for the management of supracondylar humeral fractures is also unknown at a national level.

Methods Collaborators in 129 NHS hospitals prospectively collected data on surgically managed acute paediatric orthopaedic trauma cases. Data were collected over a seven-day period and included demographics, injury characteristics, operative details and timing of surgery. A national audit was also undertaken to evaluate compliance with the British Orthopaedic Association Standards for Trauma Guideline 11: *Supracondylar Fractures of the Humerus in Children*.

Results Data were captured on 770 surgically treated cases. The three most common injuries were forearm fractures of both bones ($n=235$), distal radius fractures ($n=194$) and supracondylar elbow fractures ($n=89$). The mode day of injury was Friday ($n=136$) and the mode day of surgery was Saturday ($n=138$). 88% of supracondylar fractures received surgery on the day of presentation or the following day. Only 14% of supracondylar fractures were treated surgically after 8pm; 33/89 used 2.0mm Kirschner wires, 38/89 used 1.6mm wires and 2/89 used 1.2mm wires.

Conclusion Forearm fractures of both bones, distal radius fractures and supracondylar humeral fractures were the three most common injuries treated surgically. There is wide variation in compliance against national standards in the management of supracondylar humeral fractures with 88% undertaking surgery on the day of or the day following presentation but only 37% using the recommended 2.0mm Kirschner wires.

KEYWORDS

Supracondylar – Elbow – Paediatric – Orthopaedic – Fractures

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Introduction

Paediatric orthopaedic trauma in the UK is managed in a variety of clinical situations including emergency departments, fracture clinics and operating theatres. Acute management has been organised into paediatric major trauma centres, trauma and non-trauma units. National level activity data for all healthcare episodes are recorded by Hospital Episode Statistics.¹ However, data on paediatric acute orthopaedic trauma inpatient care are not easily identified using this database. Data on severely injured children, treated mainly in major trauma centres and specialist children's hospitals, are captured and analysed by the Trauma Audit and Research Network.² However, this only applied to major trauma patients with a significant injury severity score. Most commonly encountered paediatric orthopaedic trauma is relatively low energy and managed by the trauma units around the UK. A small fraction of all acute paediatric orthopaedic trauma is managed surgically. To date, the surgical level of activity in any given

week across the healthcare system is not clearly described. The nature and surgical management of injuries is not known. Understanding the types of cases managed surgically across the healthcare system is important for allocating provision of services both locally and regionally.

Recommendations for the management of displaced supracondylar humeral fractures in children are outlined by the British Orthopaedic Association Standards for Trauma (BOAST Guideline 11). Sixteen standards for optimal care are summarised in the guideline.

The primary aim of this study was to report the incidence of acute paediatric fractures treated surgically in the UK in a seven-day period in summer. The secondary aim was to evaluate the surgical management supracondylar elbow fractures against national guidelines. The research questions were:

1. What is the epidemiology of acute paediatric fractures treated surgically (ie having a procedure in the operating theatre) across a healthcare system?

2. How does the management of supracondylar humeral fractures compare to recommendations published in national guidelines?

Patients and methods

This study was conducted as a trainee-led multicentre audit using a trainee-developed collaborative platform (British Orthopaedic Network Environment, BONE, developed by the British Orthopaedic Trainees Association, BOTA). Collaborators were recruited via email, newsletters and at conference events such as the British Orthopaedic Association Annual Congress. All collaborators were sent a study pack via email, which included information on the study aims, standards and protocol. In the study pack, a data collection tool (Microsoft Excel) was included that permitted prospective data collection. The study cohort included all acute paediatric orthopaedic trauma cases requiring surgical intervention during the study period. The study period was seven days from 8am Wednesday 6 July to 7.59am Wednesday 13 July 2016. This was set to allow reporting of cases requiring a procedure in an operating theatre across the NHS in the UK over a seven-day period.

Collaborators were asked to prospectively collect data on surgically managed acute paediatric orthopaedic trauma at their hospital during these seven days. Once data collection was completed, the spreadsheet was emailed to the central data steering committee which analysed the data. Data were collected on demographics, injury type, surgical management and timing. Additional fields pertaining to supracondylar humeral fractures were included to allow audit against national standards (BOAST Guideline 11 *Supracondylar Fractures of the Humerus in Children*). Table 1 summarises the data collected by fields.

Audit standards

BOAST Guideline 11 contains 16 standards for clinical practice (Appendix 2, online only).⁵ Of these, three standards were identified that were amenable to a large-scale multicentre prospective clinical audit on surgically treated supracondylar fractures in children. These were standards 2, 4, and 6:

- Standard 2: ‘These injuries require early surgical treatment, ideally on the day of admission. However, night-time operating is not necessary unless there are indications for urgent surgery.’
- Standard 4: ‘Surgical stabilisation should be with bicortical wire fixation. Crossed wires are associated with a lower risk of loss of fracture reduction, whereas divergent lateral wires reduce the risk of injury to the ulnar nerve.’
- Standard 6: ‘2mm diameter wires should be used, where possible, to achieve stability.’

Results

One hundred and twenty-nine hospitals participated in the study across the UK (including one hospital in the Republic

Table 1 Data fields collected in the study including examples for each field.

Data recorded	Examples
Sex	Male, female
Injury side	Left, right, bilateral
Origin of referral	Emergency department, general practice, walk-in centre, other hospital
Age (years)	
Diagnosis	Distal radius fracture, both bone forearm fractures, supracondylar elbow fracture, lateral condyle elbow, medial epicondyle elbow, proximal humerus fracture, humeral shaft fracture, slipped upper femoral epiphysis, femoral neck fracture, femoral shaft fracture, distal femur fracture, tibial spine/tibial tubercle fracture, patellar fracture, both bone tibia/fibula shaft fracture, isolated tibial shaft fracture, distal fibula fracture, bimalleolar/trimalleolar ankle fracture, distal tibial physeal fracture (triplane, tillaux etc.)
Date of diagnosis (dd: mm:yyyy)	
Time of diagnosis (hh: mm)	
Operation type	Manipulation under anaesthesia + Kirschner wires, open reduction internal fixation, intramedullary nailing
Reduction	Closed, open
Grade of primary surgeon	Consultant, registrar, senior house officer
Operation date (dd: mm:yyyy)	
Operation time (hh: mm)	
Additional data fields recorded for supracondylar humeral fractures	
Number of wires used	2, 3, or 4
Configuration of wires	Crossed, lateral only
Width of wires	1.6mm, 2mm

of Ireland; Figure 1). A total of 770 acute paediatric fractures were managed surgically at these participating hospitals. Overall data completeness was 98.1% across all fields. Table 2 outlines the patient demographics and referral origin. Mean age was eight years (SD 3.75). The three most common injuries treated surgically were both bone forearm fractures (n=235), distal radius fractures (n=194) and supracondylar elbow fractures (n=89). Figure 2 outlines the spread of injuries requiring surgical management by frequency. Both bone forearm fractures were treated with a closed reduction in 85% of cases. The majority were treated with manipulation under



Figure 1 Geographic spread of the 129 participating hospital sites

anaesthesia and application of plaster of Paris (63%), flexible intramedullary nailing in 19% and open reduction internal fixation in 8%. For distal radius fractures, 92% were reduced closed, 63% were managed with manipulation under anaesthesia and application of plaster of Paris, and 37% required Kirschner wire (K-wire) stabilisation after reduction. The mode day of injury was Friday ($n=136$) and the mode day of surgery was Saturday ($n=138$).

For supracondylar humeral fractures ($n=89$), 70/89 (79%) were reduced closed. A total of 74/89 (83%) required manipulation under anaesthesia plus K-wires. When K-wires were required, 2 were used in 59 cases

and 3 in 15 cases. Unlike distal radius and both bone forearm fractures, supracondylar fractures were most commonly treated surgically by consultants as primary surgeon (consultant as primary surgeon in 20% for distal radius fractures, 26% in both bone forearm fractures, and 48% in supracondylar fractures).

Compliance with national standards

Standard 2: 29% of supracondylar humeral fractures had surgery on the same day of injury, with 88% having surgery on the same day or the following day. 14% of supracondylar humeral fractures were treated surgically after 8pm. As data were not collected on the surgical

Table 2 Demographic and referral origin data for common injuries

Diagnosis	Mean age (years)	Male : female	Left : right	Origin of referral			Other hospital	NR
				ED	GP	Walk-in centre		
Distal radius fractures (n= 194)	9.6	128 : 66	110 : 82 (1 bilateral)	169	0	5	19	1
Both bone forearm fractures (n= 235)	7.8	151 : 84	135 : 98	217	0	4	12	2
Supracondylar humeral fractures (n= 89)	6.5	43 : 46	49 : 39	74	0	5	10	0
All paediatric fractures (n= 770)	8.6	484 : 285	417 : 343 (4 bilateral; 1 NR)	669	3	15	78	0

ED, emergency department; GP, general practitioner; NR, not recorded

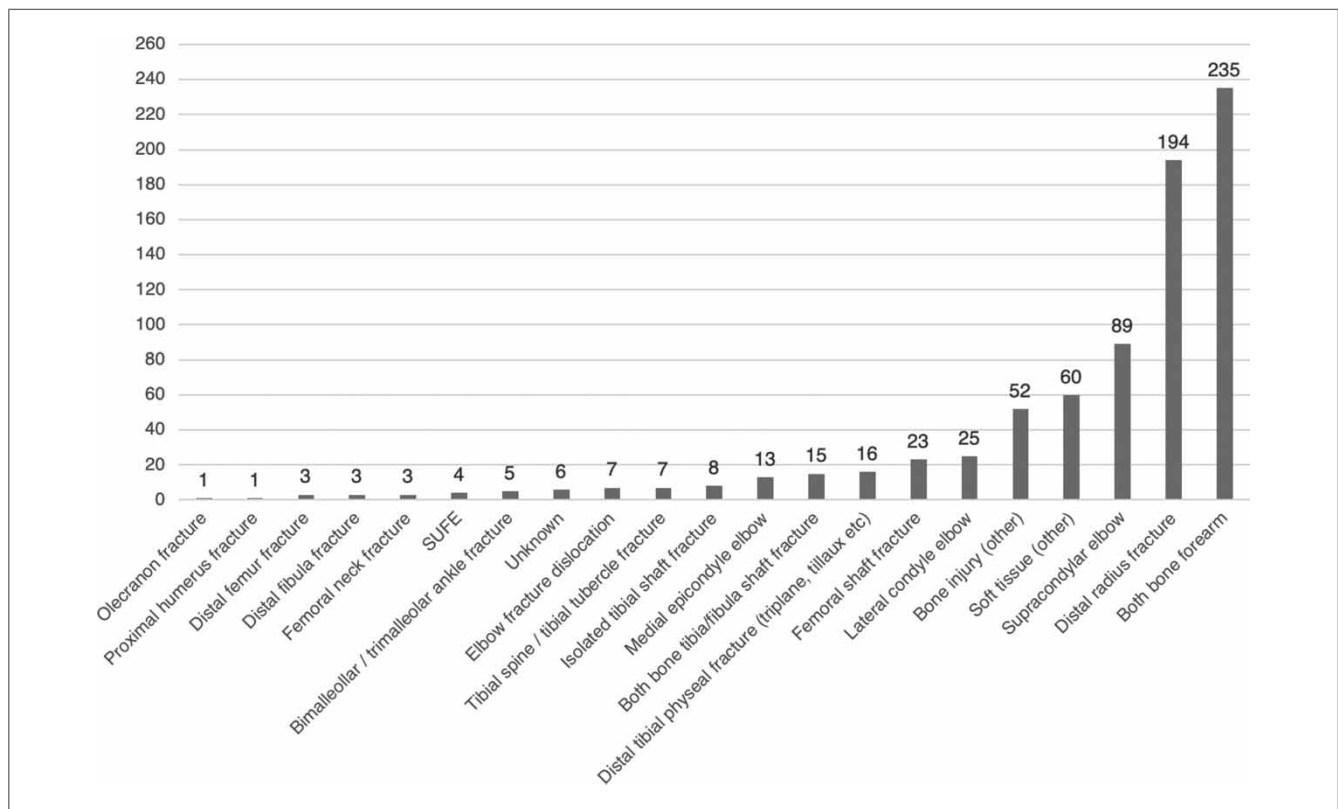


Figure 2 Chart representing frequency and range of paediatric orthopaedic injuries treated surgically

decision-making process, it is not possible to report whether these cases required emergency out of hours surgical management. Those treated surgically on the same day of injury presented to the emergency department earlier in the day than those treated the following day (mean 13:39 vs 17:49).

Standard 4: 55/89 supracondylar fractures were stabilised with crossed wire configuration, 20/89 with

lateral-only wires and 6/89 did not require K-wires. Data on K-wire configuration were not recorded for 9/89 cases.

Standard 6: 33/89 used 2.0mm K-wires, 38/89 used 1.6mm and 2/89 used 1.2mm. One confounder that may influence the decision to use 2.0mm compared with 1.6mm K-wires was the weight and hence, by proxy, the age of the child. In this study, the mean age of children with supracondylar humeral fractures requiring

manipulation under anaesthesia plus K-wire fixation with 2.0mm wires was 6.5 years compared with 6.7 years in those stabilised with 1.6mm wires, suggesting that age may not be a factor influencing choice of wire diameter in these cases.

Discussion

This study is the largest trainee collaborative of its kind; 381 collaborators captured data on 770 acute paediatric orthopaedic trauma treated surgically in 129 participating hospitals in the UK and Ireland. According to the NHS website, there are 146 acute hospital trusts that treat paediatric orthopaedic injuries. This study therefore accounts for data from approximately 88% of the NHS. The majority of patients were admitted through the emergency department (669/770). Both bone forearm fractures, distal radius fractures and supracondylar elbow fractures represented the most common types of fracture treated surgically during the seven-day study period. The most common day of admission was Friday, and Saturday was the most popular day for surgery in this cohort.

In the UK, specialist trainees in trauma and orthopaedic surgery follow a surgical curriculum.⁴ Clinical competence in the management of the breadth of paediatric orthopaedic trauma is outlined in the curriculum. Recently, assessments for manipulation under anaesthesia plus K-wiring of supracondylar humerus fractures was added to the list procedures required to complete surgical training. Trainees are now required to perform five or more of these procedures prior to completion of surgical training, and to demonstrate evidence of competence after procedural-based assessment by two consultant raters. In this snapshot study, surgical trainees performed 28/89 (31%) operations for supracondylar fractures as primary surgeon across the UK. A mean of 0.7 supracondylar fractures per hospital were treated operatively during the study period. As such, these findings suggest that it may be challenging for surgical trainees to fulfil the requirements. Several studies have reported on the learning curve for surgeons treating paediatric humeral supracondylar fractures surgically. Higher rates of inadequate reduction, malunion and increased need for open reduction were observed in surgeons with fewer than 15 cases of experience with these injuries.^{5,6} Manipulation under anaesthesia plus plaster of Paris application for both bone forearm fracture and distal radius fractures was commonly performed in this study. The assessment of competence in this skill may be more suitable and should also be considered in the next iteration of the surgical curriculum.

14% of supracondylar humeral fractures were treated surgically after 8pm. It is not clear whether these patients required emergency surgical management as the reasons for surgery or the presence of neurovascular compromise were not collected. Nearly 9 of 10

supracondylar fractures were operated on the same day of presentation or the next day, demonstrating good compliance with BOAST II guideline.² Supracondylar fractures presenting earlier in the day were more likely to undergo surgical management on the same day than those presenting later in the day. The BOAST II guideline suggests that crossed K-wire configuration is more biomechanically stable, while lateral-only wires are associated with less nerve injury. The guideline does not indicate which configuration is recommended.

Of the total, 55/89 supracondylar fractures were stabilised with cross wires, while 20/89 used a lateral-only wire configuration. Data were not collected on intraoperative decision making. The guideline reflects the best knowledge available, which comes from observational studies and biomechanical laboratory studies.⁷⁻¹⁸ There are no level 1 studies investigating the clinical effectiveness of crossed compared with lateral-only wires for displaced supracondylar fractures to inform this standard. The use of either technique may also be confounded by familiarity and training. Fracture patterns included in the audit were not characterised; in particular, degree of comminution, which may influence wire configuration used.

Surgeons used 2.0mm K-wires in 33/89 of supracondylar cases. Despite this standard explicitly recommending 2.0mm in the BOAST II guideline, this study demonstrated poor compliance. Reasons for this are not identifiable from the data collected. The mean ages of patients receiving 2.0mm wires compared with those with 1.6mm wires showed no difference.

This study has several limitations and the findings must be taken in the context of these limitations. Data were collected prospectively over a seven-day period in July. This is a short period that was chosen to reduce the data collection burden on collaborators. It only included one weekend and therefore weekly variation may exist, which potentially confounds the results. The study period was chosen to represent a typical summer week in the UK. The effect of school holidays on acute paediatric orthopaedic trauma is described.^{19,20} During the study period, schools in Scotland were on summer holiday while those in England and Wales were not. Weather is known to influence the incidence of paediatric orthopaedic trauma cases.^{20,21} Data were not collected on local weather during the study period. With 129 hospitals participating in the study from all areas of the UK (including one hospital from the Republic of Ireland), the variation in local weather may be somewhat mitigated.

The large number of participating trusts was a particular strength of this study, which permitted confidence that the findings were truly representative of acute paediatric orthopaedic trauma cases managed surgically across the NHS. Data were collected prospectively, usually by several collaborators per hospital. The accuracy of data collection was not investigated, but the study collaborators completed data on 770 cases with 98% completeness across all fields.

The study design was carefully considered to find a balance between meaningful data collection and reducing the administrative burden on collaborators. As such, it was decided to forego classification of fractures and limit the granularity of the data collected. Intraoperative decision making, neurovascular compromise and open compared with closed nature of fractures were some of the clinical features chosen not to collect data on. While collecting information in these areas would have allowed more colourful insights, the accuracy of the data collected would have been in question as these areas are often poorly documented in the case notes.²²

Conclusions

Prospectively collected data from 770 acute paediatric orthopaedic cases treated in 129 hospitals over a seven-day period is presented. Variation in compliance against national standards in the management of supracondylar humeral fractures was noted. This study provides useful data that may help hospitals with allocating resources for acute paediatric orthopaedic trauma care. This information may be particularly useful to inform the feasibility of high-quality definitive randomised controlled trials in paediatric trauma surgery in the UK.

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