Supracondylar humeral fractures in children
TEN YEARS’ EXPERIENCE IN A TEACHING HOSPITAL

J. Mangwani, R. Nadarajah, J. M. H. Paterson
From The Royal London Hospital, London, England

Although supracondylar fracture is a very common elbow injury in childhood, there is no consensus on the timing of surgery, approach for open reduction and positioning of fixation wires. We report our ten-year experience between 1993 and 2003 in 291 children.

Most fractures (285; 98%) were extension injuries, mainly Gartland types II (73; 25%) and III (163; 56%). Six (2%) were open fractures and a neurovascular deficit was seen in 12 (4%) patients. Of the 236 children (81%) who required an operation, 181 (77%) were taken to theatre on the day of admission. Most (177; 75%) of the operations were performed by specialist registrars. Fixation was by crossed Kirschner wires in 158 of 186 (85%) patients and open reduction was necessary in 52 (22%).

A post-operative neurological deficit was seen in nine patients (4%) and three (1%) required exploration of the ulnar nerve. Only 22 (4%) patients had a long-term deformity, nine (3%) from malreduction and three (1%) because of growth arrest, but corrective surgery for functional limitation was required in only three (1%) patients.

An aggressive approach for accurate reduction and stabilisation of these fractures is justified by the low incidence of long-term deformity and neurological complications. Most of these fractures occur during the day and can be treated safely on ‘twilight’ operating lists without breaching National Confidential Enquiry into Patient Outcome and Death (NCEPOD) recommendations.

Supracondylar fractures are a very common elbow injury and represent approximately 16.6% of all childhood fractures. Extension-type injuries occur in 95% of cases and associated neurovascular injuries are reported in between 5% and 30%. Extension-type injuries occur in 95% of cases and associated neurovascular injuries are reported in between 5% and 30%. 6

Treatment is based on the degree of displacement. The preferred method is closed reduction and percutaneous pinning. 7-9 Open reduction is indicated for irreducible fractures, vascular compromise and open injuries. 10,11 Medial, lateral, posterior and anterior approaches have been used and methods of fixation include lateral parallel, lateral divergent or crossed Kirschner (K-) wires.

Emergency treatment has been recommended to avoid vascular compromise and compartment syndrome. 1,3,12-16 However, recent studies 17-20 suggest that delay does not influence outcome.

There is lack of consensus on the timing of surgery, approach for open reduction and positioning of wires used for fixation. We therefore reviewed our experience of the injury.

Patients and Methods
We retrospectively reviewed the management of children younger than 15 years of age with supracondylar humeral fractures who presented to the Royal London Hospital between 1993 and 2003.

Notes and radiographs were reviewed for demographics, site and mechanism of injury, time of presentation, clinical and radiological features, time to definitive treatment, type of operation, complications and outcome. Deformity was defined as a difference of appearance between the injured and uninjured elbow, sufficient to be apparent to the patient and/or parents.

Results
A total of 341 children with unilateral supracondylar fractures was treated during the study period. We excluded 50 fractures because of inadequate records. The remaining 291 children had full documentation with a mean follow-up of 30 months (four to 60). The mean age at injury was 6.4 years (nine months to 14 years) and 186 (64%) were boys.

The injury occurred at home in 180 (62%) patients, at school in 67 (23%), in a playground in 41 (14%) and in a road traffic accident in three (1%).
The cause of injury was a fall from a height in 163 (56%) cases and a fall at ground level in 125 (43%). Two fractures resulted from personal assault in a playground.

A total of 224 (77%) children presented within two hours of injury, but 20 (7%) presented more than four hours later (Fig. 1). Their times of arrival at hospital are shown in Figure 2.

**Clinical findings.** In 177 children (61%), the dominant arm was injured. Only six cases (2%) were open injuries.

Nine children (3%) had concurrent fractures, namely seven ipsilateral forearm fractures, one femoral shaft fracture and one open tibial fracture. The initial examination was usually performed by a junior doctor. Swelling was documented in 282 (97%) fractures but deformity was noted in only 76 (26%).

Neurological examination was documented in 285 (98%) patients, with paraesthesiae noted in nine (3%) and numbness in three (1%).

Vascular examination was documented in 288 (99%) patients, with no evidence of impairment in 274 (94%). A weak radial pulse was recorded in nine patients (3%) and significant impairment with diminished capillary refill and discoloration of the fingers was seen in six (2%).

**Radiological findings.** Extension-type injuries were seen in 285 (98%) patients. The fractures were subdivided into Gartland types\(^{21}\) I (55 patients; 19%), II (73; 25%) and III (163; 56%).

**Nature of treatment.** A total of 236 (81%) patients underwent operation for type II and III fractures. Closed reduction without fixation was performed in 57 (24%), of whom five required remanipulation and K-wire stabilisation.

Closed reduction and fixation was carried out in 127 (54%) patients. Open reduction was necessary in 52 (22%) fractures. The surgical approach for open reduction was lateral in 26 (50%), medial in 21 (40%) or posterior in five (10%). There was loss of reduction in the two patients where only one K-wire was used for fixation.

K-wire fixation in 186 fractures used cross-configuration in 158 (85%), lateral divergent in 17 (9%) and lateral parallel in nine (5%). Most of the operations (177; 75%) were performed by specialist registrars at various stages of training.

Most operations (181; 77%) were on the day of admission (Fig. 3) and 45 children (19%) had surgery after 2230 hours, of whom seven (16%) had neurovascular impairment.

**Complications and outcome.** A post-operative neurological deficit was seen in seven (3%) of 236 cases that required operative intervention. Three (1%) underwent exploration...
of the ulnar nerve. In all patients, the ulnar nerve showed various degrees of bruising. No repairs were necessary and the outcome was good in all patients. The remainder recovered spontaneously within six months.

The majority (224; 77%) of patients were discharged within two to three days. A total of 12 patients (4%) had a long-term deformity (3% for malreduction and 1% for growth arrest of the distal humerus). A cubitus varus deformity was more common (nine; 3%) than valgus (three; 1%). Corrective surgery for functional limitation was required in only 1%.

Discussion
In our series, the mean age at fracture was 6.4 years, similar to other reports.22-24 Our gender ratio was 1.8:1 boy to girl. This agrees with a Chinese study,25 where boys were more commonly affected after the age of four years but contrasts with a North American study,13 which showed girls more prone to such fractures.

Our location of injury is significantly different from the other studies which showed a much lower percentage of fractures occurring at home.13,25 This may be due to the location of our hospital where a relatively large number of children live in apartment blocks without access to sports facilities.

Our cause of injury was falling from a height in 56% but from ground level in 42% contrasts with 70% and 9%, respectively, in a North American study.13 Our study reports the dominant arm to be injured more commonly compared with other studies,13,24 where the non-dominant humerus was involved.

A possible explanation is that in our series there were fewer children falling from playground equipment where there is a tendency to hang on with the dominant hand. In contrast, many of our children fell from ground level where as a natural reflex, there is a tendency to land on the dominant extended arm.

Our rates of open fracture (six; 2%) and pre-operative nerve injury (12; 4%) and concurrent fractures (nine; 3%) are consistent with the reported literature.13,25-29

In our study, 244 patients (84%) presented between 08:00 and 20:00 hours, most commonly between 12:00 and 16:00 hours. This contrasts with the North American study,13 in which 55% of the patients presented between 18:00 hours and midnight. These observations are important in relation to the timing of operation. As most of our fractures occurred during the day, we suggest that they should be dealt with on a ‘twilight’ operating list without breaching the NCEPOD recommendations.30

In our series, 163 patients (56%) had a type III fracture, a markedly higher proportion than in other series.9,23,24,28 Flexion-type fractures were seen in six patients (2%) compared with a range between 1% and 11% in the literature.25,31,32

Open reduction was necessary in 52 (22%) of our patients. The rate of open reduction reported in the literature varies from 1.3% to 46%.17,33-38 Our relatively high open reduction rate may be because of the higher proportion of severely displaced fractures (56%) and to the experience of the surgeons; 75% of operations were undertaken by specialist registrars.

The six patients (2%) presenting with significant vascular impairment and an absent radial pulse underwent emergency reduction and fixation without pre-operative angiography. In five patients, the limb regained perfusion after manipulative reduction. In one patient, the brachial artery was explored and was found to be thrombosed. We agree with others6-25 that a pre-operative angiogram in such a limb-threatening situation may lead to unnecessary delay.

Iatrogenic nerve injury was seen in nine patients (3%), which is similar to the 3.6% reported in a literature review.18 Three patients required exploration of the ulnar nerve. All had crossed K-wires with a mini-open approach for medial wire placement. There were no iatrogenic nerve injuries with lateral wires. We believe a lateral divergent configuration may be the safest without compromising stability.

Long-term deformity was seen in 12 patients (4%). Even allowing for the possibility that more recent cases have yet to demonstrate growth disturbance and deformity, this is still much less than the 30% incidence in other series.39 Only 1% required corrective osteotomy and this was for functional limitation rather than cosmetic concerns. We believe our low rate of long-term deformity is due to accurate reduction and stable fixation.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References
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