We reviewed the clinical and radiological results of six patients who had sustained traumatic separation of the distal epiphysis of the humerus at birth.

The correct diagnosis was made from plain radiographs and often supplemented with ultrasonography, MRI and arthrography. An orthopaedic surgeon saw two patients within two days of birth, and the other four were seen at between nine and 30 days. The two neonates underwent unsuccessful attempts at closed reduction. In the remaining patients, seen after the age of eight days, no attempt at reduction was made. All six displaced fractures were immobilised in a cast with the elbow at 90° of flexion and the forearm pronated.

When seen at a mean of 58 months (16 to 120) after injury, the clinical and radiological results were excellent in five patients, with complete realignment of the injury. In one patient the forearm lay in slightly reduced valgus with the elbow in full extension.

Traumatic separation of the distal epiphysis of the humerus may be missed on the maternity wards and not diagnosed until after discharge from hospital. However, even when no attempt is made to reduce the displaced epiphysis, a good clinical result can be expected.

Traumatic separation of the distal epiphysis of the humerus, first described by Smith in 1850, is a rare injury that can be seen in children up to the age of eight years. The fracture is usually the result of rotatory shear forces and is therefore typically seen following a difficult birth or child abuse. The correct diagnosis can be difficult to establish both clinically and radiologically, and the injury can be overlooked in the newborn. Also, guidelines for the management of this injury in the neonate are not well established.

We reviewed six children who sustained this injury at birth, giving special attention to the diagnosis and the appropriate management.

Patients and Methods
Four girls and two boys who sustained a traumatic separation of the distal epiphysis of the humerus at birth were managed and followed up by the authors (Table I). Four had a difficult birth and none had any other birth injury. Two were seen within two days of delivery, and the remaining four at between nine and 30 days, after discharge from hospital. The working diagnosis was non-specific fracture in three cases and a brachial plexus injury, dislocation of the elbow and elbow pain, respectively, in the others. All had swelling and tenderness of the elbow, with pseudoparalysis of the arm.

All patients had plain radiographs, three had ultrasonography, one arthrography and one MRI (Table I). A significant posteromedial displacement of the distal fragment was seen in all the initial radiographs (Fig. 1).

The choice of treatment depended on the age when the patients were first seen by an orthopaedic surgeon (Table I). One patient was diagnosed just after birth and underwent an attempted closed reduction followed by application of a cast under general anaesthesia. A minimal improvement in alignment of the distal fragment was seen (case 5, Table I, Figs 1 and 2). Another baby had significant swelling of the elbow when seen during the second day of life, and Dunlop traction was instituted for four days followed by closed reduction and immobilisation in a cast (case 2, Table I). No significant improvement in alignment was seen. The remaining four patients presented late with callus formation seen on the initial radiographs. They were treated in a cast with no attempt at reduction. In all six patients the cast was applied with the elbow in 90° of flexion and the forearm pronated.
At follow-up examination between the ages of 16 and 120 months the functional outcome was assessed and the patients examined both clinically and radiologically.

Their outcomes were compared with those in previous publications which we divided into cases with the injury sustained at birth (Table II) and those where it occurred after the age of six months (Table III).

**Results**

At a mean follow-up of 58 months (16 to 120) all patients were asymptomatic (Table I). Normal flexion was found in all patients, but one had a 5° loss of extension. Pronation and supination were normal in all patients. Five had normal carrying angles. Patient 5 had a slightly reduced valgus on the injured side compared with the normal. This was not noticed by the parents and was neither a cosmetic nor a functional problem (Fig. 2).

Radiographs at the follow-up examination showed that all the fractures had healed with complete remodelling in five patients. In one there was a slightly reduced carrying angle (Fig. 2).

From a review of the literature we found that, of 22 patients who sustained this injury at birth, 16 were treated with either closed reduction and application of a cast or with a cast alone (Table II). Only one of these (5%) developed a varus deformity.
In the search for patients who had sustained this injury after the age of six months we found 91 cases (Table III). Almost one-third of these were treated by open reduction, and the remainder had closed reduction and application of a cast or a cast alone. Of the 91 patients, 32 (35%) developed a varus deformity.

**Discussion**

Birth fractures are relatively rare. In a review of 105 119 deliveries, 789 (0.75%) of the neonates were found to have a fracture, and only one of these had sustained a traumatic separation of the distal epiphysis of the humerus. In neonates, the distal humeral physis is transverse and smooth. It represents the weakest part of the distal humerus and can fracture with a rotational shear force. With growth, it becomes more oblique and irregular, which explains why these forces will then usually cause a supracondylar fracture in children over six years of age. This was confirmed by Dameron, who tried to produce a supracondylar fracture of the humerus in eight stillborn children but instead created a traumatic separation of the distal epiphysis of the humerus in all cases.

The injury can easily be missed, and it is likely that some patients will never be diagnosed as the swelling and pain reduce after a few weeks. Four of our patients were diagnosed late, between the ages of nine and 30 days.

Clinical examination usually shows a swollen elbow, pseudoparalysis and 'muffled crepitus' on movement, representing cartilage moving against cartilage.

Plain radiographs will usually establish the diagnosis and comparison with films of the opposite elbow can frequently be of value. The key to diagnosis is the altered relationship between the distal humerus and the proximal forearm which is displaced posteromedially. An anterolateral displacement of the distal fragment has also been described in a case where the mechanism of injury was hyperflexion of the elbow during delivery.

Ultrasonography can demonstrate the cartilaginous part of the distal humerus in relationship to the forearm (Fig. 3), and this confirmed the diagnosis in three of our cases.

MRI can be helpful, but as the patient usually needs sedation we feel that it is rarely needed (Fig. 4).

One patient had an arthrogram, which outlined the fracture nicely. However, this is an invasive procedure and was only used in our first patient (1988), when ultrasonography and MRI were not yet routinely available. This patient is included in the present study.
The differential diagnosis includes dislocation of the radial head, which has also been described after a difficult birth.11 Dislocation of the elbow will give an altered relationship between the distal humerus and forearm, and is a common incorrect initial diagnosis. A traumatic dislocation of the elbow has not, to our knowledge, been described in children under four years of age.12

The recommendations for treatment for traumatic separation of the distal epiphysis of the humerus in the newborn and child differ widely, but all authors agree that the fracture usually heals. There is only one published case of nonunion13 and only one in which permanent damage to the physeal remained.14

Kasser and Beaty2 recommended immobilisation in a cast with the elbow in 90° of flexion, and the forearm in full pronation to stabilise the fracture in neonates. Conversely, Price15 advocated closed reduction and percutaneous pinning. Mizuno et al13 recommended open reduction through a posterior approach with pinning, and found no post-operative deformity. De Jager and Hoffman16 found that 12 of 48 children (0 to 8 years of age) had a varus deformity at follow-up, with a higher frequency of varus in children less than two years of age. He therefore recommended closed reduction and pinning, but could not explain the varus deformity in three of the ten children who had open reduction and pinning.

The varus deformity that seems to be the most common complication of traumatic separation of the distal epiphysis of the humerus is usually not progressive and therefore unlikely to be caused by a physeal injury.17 It is believed

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**Table III.** Summary of the literature on patients treated for traumatic separation of the distal epiphysis of the humerus sustained after the age of six months

<table>
<thead>
<tr>
<th>Author/s</th>
<th>Number of cases</th>
<th>Initial wrong diagnosis (days)</th>
<th>Treatment</th>
<th>Outcome for carrying angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marmor and Bechtol30</td>
<td>1</td>
<td>1</td>
<td>Cast without reduction</td>
<td>Varus: 1†</td>
</tr>
<tr>
<td>Kaplan and Reckling31</td>
<td>1</td>
<td>0</td>
<td>Closed reduction and cast</td>
<td>Normal</td>
</tr>
<tr>
<td>Chand32</td>
<td>1</td>
<td>0</td>
<td>Closed reduction and cast</td>
<td>Normal</td>
</tr>
<tr>
<td>Mizuno et al13</td>
<td>6</td>
<td>6/6</td>
<td>Open reduction and cast; 5 Traction: 1</td>
<td>Valgus: 1†</td>
</tr>
<tr>
<td>Holda et al33</td>
<td>7</td>
<td>5/7</td>
<td>Open reduction and cast; 4 Traction: 2</td>
<td>Varus: 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Closed reduction and traction: 2</td>
<td>Normal: 2†</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No treatment: 1</td>
<td></td>
</tr>
<tr>
<td>DeLee et al17</td>
<td>12</td>
<td>8/12</td>
<td>Closed reduction and cast; 9 No treatment: 3</td>
<td>Varus: 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Reduced carrying angle: 6†</td>
<td></td>
</tr>
<tr>
<td>Peiro et al34</td>
<td>5</td>
<td>3/5</td>
<td>Closed reduction and cast; 3 Open reduction and cast: 2</td>
<td>Varus: 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Normal: 5†</td>
</tr>
<tr>
<td>McIntyre et al35</td>
<td>12</td>
<td>5/12</td>
<td>Open reduction and cast; 7 Closed reduction and cast: 4 No treatment: 1</td>
<td>Varus: 4†</td>
</tr>
<tr>
<td>Akbarnia et al8</td>
<td>4</td>
<td>†</td>
<td>Closed reduction and cast; 3 Open reduction and pinning and cast: 1</td>
<td>Varus: 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Normal: 2†</td>
</tr>
<tr>
<td>De Jager and Hoffman16</td>
<td>12</td>
<td>4/12</td>
<td>Both open and closed reduction and cast</td>
<td>Varus: 3 Reduced carrying angle: 2 Normal: 4†</td>
</tr>
<tr>
<td>Abe et al14</td>
<td>13</td>
<td>†</td>
<td>Open reduction and pinning and cast: 6 Closed reduction and pinning and cast: 5 Skin traction: 2</td>
<td>Varus: 7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Normal: 5†</td>
</tr>
<tr>
<td>Oh et al36</td>
<td>12</td>
<td>†</td>
<td>Closed reduction and cast; 4 Closed reduction and pinning and cast: 6 Cast: 2</td>
<td>Varus: 7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Normal: 5</td>
</tr>
<tr>
<td>Tudisco et al37</td>
<td>5</td>
<td>0</td>
<td>Closed reduction and cast; 4 Cast without reduction: 1</td>
<td>Varus: 1 Reduced cubitus valgus: 4†</td>
</tr>
<tr>
<td>Total (%)</td>
<td>91</td>
<td></td>
<td></td>
<td>Varus: 32 (35)</td>
</tr>
</tbody>
</table>

* some patients had slightly reduced range of movement
† incomplete data
that the varus is caused by a medial tilt of the distal fragment if the fragment is internally rotated.\textsuperscript{17} Cubitus varus has also been described after osteonecrosis of the humeral trochlea, probably due to a vascular injury.\textsuperscript{18}

The published reports (Tables II and III) confirm that a varus deformity is rare when the injury is sustained in the newborn but more common when it is sustained after the age of six months. This could be due to the superior remodelling capacity of the neonate.

None of our patients was treated by open reduction, and anatomical alignment was not achieved in the two who had closed reduction and casting. In the remaining four children no attempts were made to reduce the displaced fractures, as the initial radiographs revealed callus. It is believed that in all six children the fractures united with the distal fragment displaced posteriorly and medially. However, at follow-up the posterior displacement had completely corrected in all patients, and in the anteroposterior view a slight varus deformity was seen in only one patient, which was not clinically noticeable (Fig. 2).

The benign outcomes of our six patients suggest that neither manipulative nor operative treatment is necessary in traumatic separation of the distal epiphysis of the humerus in the neonate. We recommend that a cast is applied for between two and four weeks, with the elbow in 90° of flexion and the forearm in pronation.

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


