OBSERVATIONS CONCERNING FRACTURES OF THE LATERAL HUMERAL CONDYLE IN CHILDREN

Roly Jakob, Toronto, John V. Fowles, Montréal, Mercer Rang, Toronto, Canada, and Mohamed T. Kassab, Tunis, Tunisia

From the Hospital for Sick Children, Toronto, and the Centre d’Orthopédie, Kassar Said, Tunis

From an anatomical study and clinical review of fractures of the lateral humeral condyle in children, the following conclusions are drawn. The mechanism of injury is a violent varus force with the elbow in extension, the condyle being avulsed by the lateral ligament and the extensor muscles. If the fracture is incomplete, with an intact hinge of pre-osseous cartilage medially, the fragment will not be displaced. If the fracture is complete the fragment may be displaced, and open reduction with internal fixation is mandatory. The results of open reduction more than three weeks after the fracture are no better than those of no treatment at all, and may kill the lateral condylar fragment by damaging its blood supply. The major problem of a neglected fracture is tardy ulnar nerve palsy; to avoid this, immediate anterior transposition of the nerve is recommended, operation for the fracture itself being of no benefit.

During a clinical and radiological review of twenty-six children with displaced fractures of the lateral humeral condyle, the following questions were raised: 1) What is the mechanism of injury? 2) Is there an inherent anatomical difference between displaced and undisplaced fractures? 3) What is the best treatment for the child who is seen late?

This paper presents an anatomical study and a clinical review of fractures of the lateral humeral condyle in children, and provides some answers to these questions.

ANATOMICAL STUDY

Anatomical studies were performed at necropsy in the Pathology Department of the Hospital for Sick Children. The ages of the children, all of whom had died from violent injuries, were between two and a half and ten years. The following methods were used. With the upper arm fixed, valgus and varus forces were applied in supination and pronation. In another group, anteriorly and posteriorly directed forces were applied to the olecranon with the elbow flexed to a right angle. In every case radiographs were made with the elbow in maximum

![Fig. 1](image1.png)  
**FIG. 1** Forced adduction of left elbow leaving intact cartilage hinge. Figures 1 and 2—Forced adduction: the cartilage hinge allows angulation but anchors the fragment. Figures 3 and 4—After putting the arm in a normal position the fragment almost returns to its place.

![Fig. 2](image2.png)

![Fig. 3](image3.png)

![Fig. 4](image4.png)

Dr Roly Jakob, Orthopaedic Department, Inselspital, University of Berne, Switzerland.
Dr John V. Fowles, F.R.C.S.(C), 723 Stuart Avenue, Outremont, Montréal, P.Q., Canada H2V 3H1.
Dr Mercer Rang, F.R.C.S., Department of Orthopaedics, Hospital for Sick Children, 553 University Avenue, Toronto, Ontario, Canada.
Dr Mohamed T. Kassab, Centre d’Orthopédie, Kassar Said, Tunis, Tunisia.
Observations concerning fractures of the lateral humeral condyle in children

Fig. 5
Fig. 6
Fig. 7
Fig. 8

Forced adduction followed by surgical division of the cartilage hinge. Figures 5 and 6—The air arthrograph shows the divided hinge. Even though little displaced the fragment has moved laterally. The lateral shift distinguishes this from the appearance in Figures 3 and 4 in which the fragment was not shifted laterally because the hinge was intact. Figures 7 and 8—After manipulation the fragment is free to rotate.

Fig. 9
Fig. 10
Fig. 11

Dissection of the same elbow from in front. T=trochlea; C=capitulum; R=radial head; M=humeral metaphysis. Figure 9—The intact hinge. Figure 10—After division of the hinge. Figure 11—After manipulation the fragment rotates.

Substantial bridge of cartilage (Figs. 1 to 4). When the arm was repositioned this bridge acted as a hinge, guiding the fragment back into position, preventing displacement, maintaining an intact articular surface, and closing the fracture line. In the fourth case the forearm was loaded axially and the elbow forced into valgus after the fracture had been produced by the method previously described. The cartilage hinge in this instance was very thin, and after division of this with a scalpel the condylar fragment moved laterally and could easily be rotated by direct manipulation (Figs. 5 to 11).

To determine the ratio of undisplaced to displaced fractures at the Hospital for Sick Children the records for the previous three years were examined. Of forty-eight children with fractures of the lateral condyle treated during the period, twenty had minimally displaced fractures and were treated successfully by immobilisation in plaster. The remaining twenty-eight children had displaced fractures which required open reduction and internal fixation.

Clinical review

Twenty-six children with displaced fractures of the lateral humeral condyle were treated in the orthopaedic unit in Tunis between 1965 and 1972, and are the subject of this review. All the patients were boys between three and ten years old, the average age being seven. The fracture was on the left side in sixteen children. Four patients had a Milch type 1 injury, the fracture line crossing the capitular epiphysis and entering the joint lateral to the trochlea; the rest had type 2 injuries, the fracture fragment including the capitulum and the lateral part of the trochlea. In all patients the condylar fragment was displaced, and in fourteen cases it was rotated as well. In nine children the elbow was subluxated laterally, and in three it was subluxated medially. An adduction type of transverse fracture of the olecranon was present in two patients (Fig. 12).

Thirteen patients were treated within eight days of the fracture, and are in group 1. Seven patients came to the orthopaedic service between three weeks and three
months after the fracture, and comprise group 2. The six patients in group 3 were first seen more than three months after the fracture and were not treated.

TREATMENT

The thirteen patients in group 1 were treated within eight days of the fracture. All had open reduction by the lateral approach described by Boyd (1971), the fragment being secured by two fine Kirschner wires (Fig. 13). The arm was then supported in a plaster splint with the elbow at 90 degrees and the forearm in neutral rotation. Four weeks later the plaster and wires were removed and the child started moving the arm. One patient had a pin track infection which was cured by local treatment. There were no other complications.

The seven patients in group 2 were first seen between three weeks and three months after the fracture (Table I). All seven patients had open reduction of the fracture by the lateral approach (Figs. 15 and 16). Because of the delay in treatment the fracture surfaces were covered with fibrous tissue and callus, losing their contours, and

<table>
<thead>
<tr>
<th>Patient number</th>
<th>Age at injury (years)</th>
<th>Side</th>
<th>Delay between injury and treatment (weeks)</th>
<th>Length of follow-up after treatment (months)</th>
<th>Range of movement before treatment (degrees)</th>
<th>Range of movement at follow-up (normal side in brackets) (degrees)</th>
<th>Radiological result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>Left</td>
<td>3</td>
<td>30</td>
<td>30/100</td>
<td>30/100 (0/150)</td>
<td>Avascular necrosis. Malunion. Early closure of epiphysial plate</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>Right</td>
<td>3</td>
<td>22</td>
<td>10/140</td>
<td>10/140 (0/150)</td>
<td>Early closure of epiphysial plate. Increased valgus, 5 degrees</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>Right</td>
<td>12</td>
<td>48</td>
<td>60/100</td>
<td>60/100 (0/145)</td>
<td>Malunion. Lateral subluxation</td>
</tr>
<tr>
<td>4</td>
<td>9</td>
<td>Right</td>
<td>9</td>
<td>37</td>
<td>45/120</td>
<td>45/120 (0/145)</td>
<td>Avascular necrosis</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>Left</td>
<td>7</td>
<td>33</td>
<td>45/100</td>
<td>45/100 (0/145)</td>
<td>Non-union. Lateral subluxation. Increased valgus, 10 degrees</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>Right</td>
<td>10</td>
<td>35</td>
<td>35/90</td>
<td>35/90 (0/145)</td>
<td>Avascular necrosis. Malunion. Lateral subluxation</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>Right</td>
<td>6</td>
<td>20</td>
<td>90/90</td>
<td>90/90 (0/140)</td>
<td>No abnormality</td>
</tr>
</tbody>
</table>

THE JOURNAL OF BONE AND JOINT SURGERY
the joint cavity was filled with organising haematoma. Before the fracture could be reduced, therefore, the scar tissue and callus had to be removed, a task made difficult because it was hard to differentiate between the callus and the fracture surfaces, and even at times between the fibrous tissue in the joint and the cartilaginous articular surfaces. Accurate orientation of the rotated condyle was all but impossible because it was bereft of its landmarks; and in cleaning off the scar tissue, and freeing the lateral condyle sufficiently to derotate it for accurate reduction, the soft-tissue attachments were frequently damaged, thus jeopardising the blood supply of the fragment. Where the elbow was subluxated or dislocated, this had to be reduced too, and was an additional source of difficulty in these old injuries. When reduction of the fracture had been attained, it was held with two Kirschner wires and verified by radiographs. The post-operative management was similar to that of the recent fractures. There were no early complications.

The six patients in group 3 came to the service between three months and seven years after the fracture, four of them having been treated with plaster splints without reduction (Fig. 18). They received no further treatment for the fracture other than active mobilisation,

<table>
<thead>
<tr>
<th>Patient number</th>
<th>Age at injury (years)</th>
<th>Side</th>
<th>Delay between injury and first visit (months)</th>
<th>Length of follow-up since injury (months)</th>
<th>Range of movement at follow-up (normal side in brackets) (degrees)</th>
<th>Clinical result</th>
<th>Radiological result</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>8</td>
<td>Right</td>
<td>15</td>
<td>46</td>
<td>5/125 (0/140)</td>
<td>Some pain on all movements</td>
<td>Early closure of epiphysial plate. Malunion with marked fish-tail</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
<td>Left</td>
<td>48</td>
<td>60</td>
<td>0/150 (0/150)</td>
<td>Valgus increased 15 degrees. Weak hand grip</td>
<td>Non-union. Dislocation</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>Right</td>
<td>84</td>
<td>96</td>
<td>0/145 (0/145)</td>
<td>Valgus 30 degrees. Ulnar nerve palsy. Anterior transposition, improved sensation but not motor power</td>
<td>Non-union</td>
</tr>
<tr>
<td>11</td>
<td>8</td>
<td>Left</td>
<td>No delay, but injury recognised and untreated</td>
<td>68</td>
<td>15/140 (0/140)</td>
<td>Valgus 20 degrees</td>
<td>Subluxation. Malunion. Early closure of epiphysial plate</td>
</tr>
<tr>
<td>12</td>
<td>5</td>
<td>Left</td>
<td>14</td>
<td>No follow-up</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>4</td>
<td>Left</td>
<td>15</td>
<td>28</td>
<td>30/110 (0/140)</td>
<td></td>
<td>Non-union</td>
</tr>
</tbody>
</table>
and were seen at intervals in the out-patient clinic (Table II).

RESULTS

In group 1 eleven of the thirteen patients were seen for follow-up an average of two years after the fracture, with a minimum of one year and a maximum of four years (Fig. 14). Clinically all the patients had normal elbows, with a full range of movement and a carrying angle equal to that of the other arm; radiologically all were normal except for three who had a mild fish-tail deformity of the distal end of the humerus. Two patients did not return for follow-up.

All seven patients in group 2 were seen at an average of three years after operation, with a minimum of one and a half and a maximum of four years. Every patient had some limitation of movement, the average loss being 34 degrees, or 22 per cent, when compared with the uninjured elbow (Table I). Two patients had a valgus deformity, and two had a prominent mass on the lateral side of the elbow. Radiologically three patients had avascular necrosis of the lateral condyle (Figs. 19 and 20). One patient had non-union (Fig. 17) and three had mal-union. Three patients had persistent subluxation of the joint; and in two patients the lateral part of the distal humeral growth plate closed prematurely.

Of the six patients in group 3, not treated by operation, five returned for follow-up and were seen an average of five years after the fracture, with a minimum of two and a half and a maximum of nine years. Two patients had a full range of movement (Table II). The other three had lost an average of 31 degrees, or 21 per cent compared to the normal side. In all three patients in whom the carrying angle could be measured there was valgus deformity. One patient complained of pain; one had a complete tardy ulnar nerve palsy, the symptoms starting four years after the injury; another patient complained of weakness of grip, though on examination the sensation and motor power were normal. Radiologically there were three cases of non-union, one with dislocation of the elbow, and two cases of malunion in one of which there was persistent subluxation. None of these five patients had avascular necrosis of the capitulum.

DISCUSSION

A variety of mechanisms has been suggested as causing this fracture, such as a fall on the hand with the elbow flexed or extended, the forearm in varus or valgus, or a direct blow on the elbow itself (Mouchet 1898; Stimson 1907; Ashhurst 1910; Wilson 1936; Röhl 1953; Blount 1955; Milch 1956; Maylahn and Fahey 1958; Böhler 1966; Sharrard 1971; Smith 1972). Malgaigne (1859) said that when the violence of the injury was sufficient the elbow was dislocated, and McLearie and Merson (1954) believed that the fracture was always accompanied by a dislocation and that this was responsible for the displacement and rotation of the condyle rather than the pull of the extensor muscles. Mouchet in 1898, and later Stimson (1907), reproduced the fracture in cadavers by applying an adduction force to the forearm with the elbow in extension and the forearm in supination. Mouchet stated that the condyle and lateral part of the trochlea were split off by the trochlear ridge of the ulna.

In the anatomical study reported here the fracture was reproduced only by adducting the supinated forearm with the elbow in extension. The fracture line started on the lateral aspect of the condyle, suggesting that the condyle was being pulled off by the lateral ligament of

THE JOURNAL OF BONE AND JOINT SURGERY
the elbow and the long extensor muscles. This confirms the observations of other authors (Judet 1922; Speed and Macey 1933; Wilson 1936; Röhl 1953; Watson-Jones 1955; Maylahn and Fahey 1958; Böhler 1966; Hardacre, Nahigian, Fromison and Brown 1971; Smith 1972; Wadsworth 1972). All of the fractures produced in the cadaver elbow were incomplete, the pre-osseous cartilage of the humeral epiphysis acting as a hinge and allowing the fracture to open like a book, but preventing gross displacement and rotation of the condyle. As soon as this hinge was divided the fracture became unstable, and the condyle could then be displaced and rotated without difficulty. It seems likely therefore that an undisplaced fracture of the lateral condyle is of the incomplete type, whereas a displaced fracture is certainly complete. At the Hospital for Sick Children undisplaced fractures comprised nearly half of all the lateral condylar fractures that were treated over a three-year period.

In all cases in which the olecranon was fractured, both in the anatomical study and the clinical review, the fracture was of the adduction type, suggesting that in extension the trochlea was locked in the olecranon fossa of the humerus, and as the forearm was violently adducted the olecranon fractured, the fracture line opening on the radial side (Fig. 12).

Although closed reduction of the displaced fracture is still sometimes advocated, most authors agree that prompt open reduction and internal fixation give the best results (Speed and Macey 1933; Wilson 1936; McDonnell and Wilson 1948; Röhl 1953; Badger 1954; Blount 1954; Wilson 1955; Jeffery 1958; Maylahn and Fahey 1958; Freeman 1959; Lagrange and Rigault 1962; Crabbe 1963; Conner and Smith 1970; Salter 1970; Hardacre and colleagues 1971; Wadsworth 1972). The results of early treatment reported in this paper are all good, and are similar to the results of these authors. An occasional radiological finding was the mild fish-tail deformity of the distal end of the humerus which was due perhaps to damage to the growth plate immediately adjacent to the fracture line. Other authors have reported this abnormality, and stated that it may produce cubitus valgus with limitation of movement, or even progress to degenerative arthritis (Wilson 1955; Wadsworth 1964, 1972). None of our three patients with this abnormality had a deviation of the carrying angle; nor did they lose any mobility of the elbow.

The child who comes with a neglected fracture three weeks old or more poses a problem of treatment. Though Wilson (1936) and Böhler (1966) stated that open reduction should be done even for the late cases, and Speed and Macey (1933) thought this should be done for malunion and non-union, other authors state that delayed open reduction is unsatisfactory (Speed and Macey 1933; Wilson 1936; Röhl 1953; Blount 1954; Maylahn and Fahey 1958; Lagrange and Rigault 1962; Hardacre and colleagues 1971; Smith 1972; Wadsworth 1972). Our results in seven children who had delayed open reduction and fixation of the lateral condyle are poor. Of these seven patients in group 2, not one had a normal elbow, and although non-union, malunion, persistent subluxation of the elbow and limitation of movement occurred in both groups 2 and 3, it was only in group 2 that the lateral condyle became necrotic, suggesting that this was caused during operation by stripping the soft-tissue attachments from the fragment. Both Haraldsson (1959) and Lagrange and Rigault (1962) showed that the blood supply to the lateral condyle enters by its soft-tissue attachments, particularly posteriorly at the origin of the long extensor muscles, and disruption of this will destroy the vessels and render the condyle ischaemic. None of these complications occurred among the children who were treated early (Group 1).

As others found (Hamilton 1880; Moorhead 1919; Röhl 1953; Watson-Jones 1955; Lagrange and Rigault 1962; Boyd 1971; Hardacre and colleagues 1971), there was some reduction of function of the elbow among the patients in group 3, but these were functionally no worse than those in group 2. The major problem in the untreated patient is not the elbow itself, but rather the possibility of tardy ulnar nerve palsy, and this is reflected in the figures of Gay and Love (1947) who showed that a quarter of the patients seen at the Mayo Clinic with tardy ulnar nerve palsy had had a fracture of the lateral condyle. This raises the question of how one should treat the child who comes with a fracture three weeks old or more. Kocher (1896) (cited by Stimson in 1907), Scudder (1938) and Smith (1972) advocated excision of the fragment for the unreduced fracture several months old, but this does not solve any of the problems since the valgus deformity may well become worse and increase the chance of ulnar nerve palsy (Böhler 1966; Sharrard 1971). Mouchet (1914) thought that the nerve transposed anteriorly was too superficial and liable to injury, and he proposed a cuneiform osteotomy of the distal humerus after symptoms of neuritis had appeared. Blount (1954) and Böhler (1966) suggested an osteotomy of the distal humerus at the end of growth, followed by ulnar nerve transposition as soon as neurological symptoms were noticed, while Wilson (1936) advised an early osteotomy for valgus in order to avoid a neuropathy. But the prophylactic value of an osteotomy is uncertain because the nerve remains in its gutter behind the medial epicondyle, and is prone to irritation in the event of a post-traumatic arthritis of the elbow (Vanderpool, Chalmers, Lamb and Whiston 1968). And because the relationship between the medial epicondyle and the laterally subluxated olecranon remains unchanged after an osteotomy, the arcuate ligament covering the nerve in its tunnel remains taut, and may continue to compress the nerve (Wadsworth 1972). Gay and Love (1947) said that, if open reduction of the fracture was necessary and a deformity likely to result, the nerve should be transposed anteriorly at the same time. Other authors (McGowan 1950; Watson-Jones 1955; Lagrange and Rigault 1962; Boyd 1971;
Hardacre and colleagues (1971; Smith 1972) have said that early transposition of the nerve is advisable before the changes in the nerve trunk became irreversible, and Smith (1972) added that the patient should be warned of the early signs of neuritis, and told to report to his doctor immediately if he noticed them. Wadsworth (1972) said: "... the earlier surgical treatment is performed once ulnar nerve palsy has commenced, the better the result will be." We would add that if treatment is instituted before ulnar nerve palsy has started, the result will be even better. We consider that the nerve should be transposed when the child with a neglected fracture is seen for the first time, before neurological symptoms appear. It would then be unnecessary to rely on the patient to report his earliest symptoms. We do not advocate treatment of the ununited or malunited condyle, nor correction of the valgus deformity, since these operations seldom improve the function of the elbow joint itself and do not alter the vulnerability of the ulnar nerve.

We wish to express our gratitude to Dr J. Huber, Chief of the Department of Pathology at the Hospital for Sick Children, and his staff for their assistance. Also to Dr Bernard Nolan for his help in recalling some of the patients.

The clinical review was conducted while one of the authors (J. V. F.) was the Senior Medical Officer with CARE-Medico in Tunisia.

REFERENCES


Kocher, I. (1886) Beiträge zur Kenntnis einiger praktisch wichtiger Frakturformen. Cited by Stimson.


THE JOURNAL OF BONE AND JOINT SURGERY