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SUPRACONDYLAR FRACTURE OF THE HUMERUS IN CHILDREN

A Long-Term Follow-up Study of 107 Cases

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A total of 107 cases of supracondylar fracture of the humerus in children were examined after a follow-up period of 8 to 18 years. No serious complications were found. Conservative treatment gave good results, and open reduction was seldom indicated. Rotational displacement and displacement in the frontal or sagittal plane remodelled by the end of the growth period, whereas tilting of the distal fragment into varus or valgus remained. The position of reduction should be checked roentgenologically until bony consolidation occurs, by measuring Baumann's angle or the carrying angle, and rereductions should be performed within 2 weeks.

Key words: supracondylar fracture; humerus; children; Dunlop's traction; long-term follow-up

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Supracondylar fracture of the humerus is a common fracture in children. Between 40 and 60 per cent of all fractures in the elbow region are of this type (Blount et al. 1951, Blount 1955, El-Sharkawi & Fattah 1965, Henrikson 1966). The treatment of these fractures presents certain difficulties even to experienced surgeons. It is common to classify supracondylar fractures into two main groups according to the direction of the force of the injury: the rare flexion type which constitutes 1 per cent of cases according to Blount (1955), and the more common extension type of fracture. Good results after closed reduction and immobilization of the elbow joint into flexion and pronation have been reported by many authors (Baumann 1929, Siris 1939, Blount et al. 1951, Blount 1955, Watson-Jones 1962, Charnley 1963, Sharrard 1971, Izadpanah 1973). Many extension-type fractures may be immobilized in extreme flexion with a collar and cuff, without the use of plaster (Blount et al. 1951. Watson-Jones 1962, Charnley 1963).

El-Sharkawi & Fattah (1965) treated supracondylar fractures with reduction and immobilization of the elbow joint in full extension and supination. Baumann (1929) recommended traction in severely displaced cases, especially if the patients came for treatment late. Skin traction after reduction was introduced by Dunlop (1939). The same method was used later by Allen & Gramse (1945), Mitchell & Adams (1961) and Dodge (1972). Hagen (1964) used skin traction over the head. Skeletal olecranon traction was used by Høyer (1952), Madsen (1955), Smith (1960, 1967) and Rosman (1975). This latter method was preferred as treatment for severely displaced fractures by Sharrard (1971) and Tachdjian (1972). Swenson (1948), Flynn et al. (1974) and Fowles & Kassab (1974) preferred closed reduction of the fracture with fixation of the fragments by

percutaneous Kirschner or Steinmann wires.

This paper presents an investigation of the treatment of supracondylar fractures of the humerus in children comparing treatment by closed reduction and plaster immobilization with treatment by reduction, traction and plaster immobilization, as regards end results and growth disorders. We also tried to determine the range of displacement which could be accepted primarily if a good end result was to be obtained.

PATIENTS AND METHODS

The series consisted of 107 dislocated supracondylar fractures of the humerus in children under 15 years of age, treated as inpatients at Aurora Children's Hospital, Helsinki, Finland, in the period in 1957–1967. Of the total number of 176 patients, 36 were excluded from our study, because there was neither fracture dislocation nor reduction. 107 out of 140 inpatients (76 per cent) were contacted and examined by the authors during 1973–1975. Some of the remaining 33 patients (33/140) were excluded because of the unacceptable quality of the primary radiographs.

The age and sex distribution is shown in Figure 1. The age of the patients varied from 1.5 to 14 years with an average of 7 years. The highest frequency of fractures was found in the age group 3 to 9 years. The ratio between left and right sides was 67:40. Fractures were sustained most frequently during the summer and autumn. The cause of the injury is presented in Table 1. There were no open fractures. The fractures were classified into five groups according to the mechanism of the trauma and the degree of dislocation (Figure 2). Flexion-type fracture (groups II and III) occurred in 12 cases (11 per cent), and the extension-type (groups IV and V) in 87 cases (81 per cent). Eight cases (8 per cent) with only rotational displacement made up group I.

Treatment was closed reduction and plaster immobilization in 35 cases (32 per cent), reduction and Dunlop's skin traction in 58 cases (54 per cent) (Figure 3). Seven cases (7 per cent) were immobilized without reduction and seven cases (7 per cent) were treated surgically (Table 2). In the seven surgically treated cases conservative reduction was tried first without success, but because of loss of the pulse in the radial artery in four cases and failure to maintain an acceptable position of the fracture with closed reduction in three cases, open reduction was performed

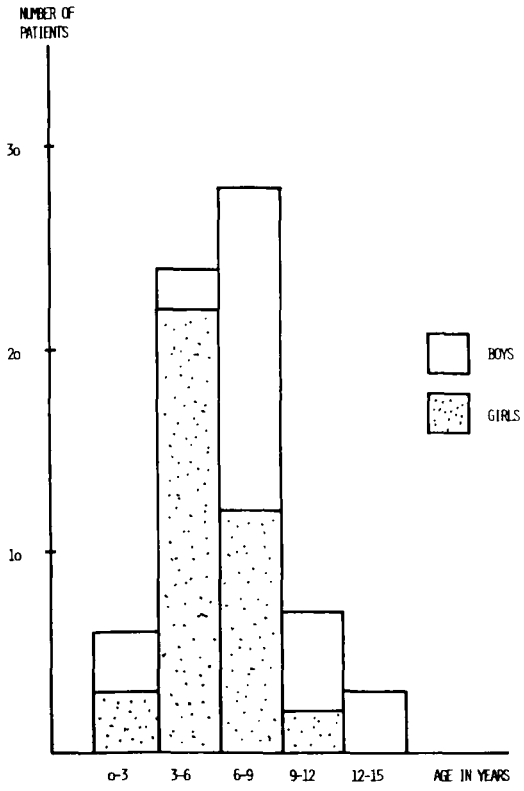


Figure 1. Distribution of the fracture cases according to age in years at the time of injury.

including fixation of the fragments with Kirschner wire or cerclage.

The flexion-type fractures were immobilized with the elbow joint in full extension and supination. Dunlop's skin traction was used in cases of severe posterior dislocation and in cases where reduction could not be retained in plaster. Rereductions were done in 25 cases. Traction was maintained for 4 to 28 days, after which the traction was removed and the arm was immobilized with plaster. The total period of immobilization lasted on average 30 days.

Residual deformity was studied radiologically. In order to estimate varus or valgus deformity, the angle between the lateral epiphyseal line and the

Table 1. Mechanism of the injury

Fall from a height	60
Fall on the same level	29
Sports accident	17
Compression/twisting	1
Total	107

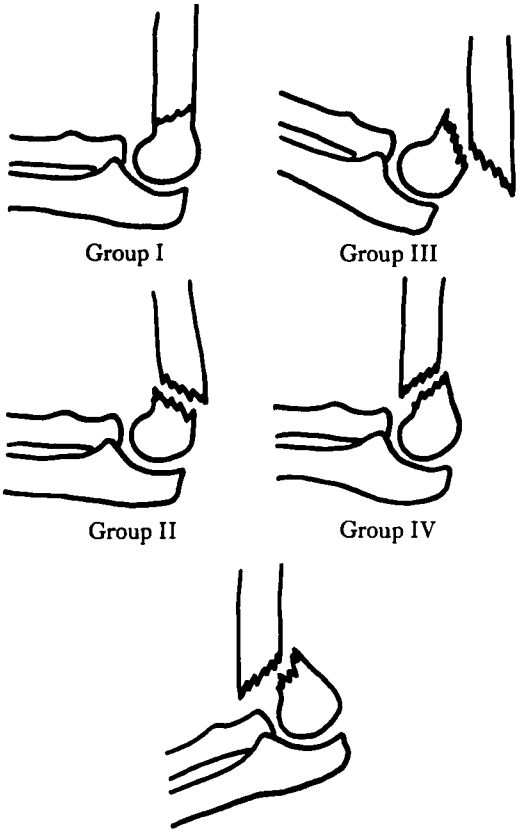


Figure 2. The distribution of the fractures in the different groups of displacement in the sagittal plane (Henrikson 1966; with the author's permission).

Group I
No displacement (according to Henrikson) but the eight cases in our series with only slight rotational displacement are included in this group.
Group II
Apex of angle (< 20°) dorsally and/or with anterior displacement less than the breadth of the bone. Four patients.
Group III
Apex of angle (> 20°) dorsally and/or anterior displacement equal to the breadth of the bone. Eight patients.
Group IV
Apex of angle (< 20°) anteriorly and/or dorsal displacement less than the breadth of the bone. Twenty-two patients.
Group V
Apex of angle (> 20°) anteriorly and/or dorsal displacement of the distal fragment by more than the breadth of the bone. Sixty-five patients.

Figure 3. Modified Dunlop's skin traction with posterior plaster splint.

longitudinal axis of the humerus was measured according to Baumann (1929) (Figure 4). After the closure of the epiphyseal lines, an analogous comparison of the angle between the trochlear axis and the longitudinal axis of the humerus, the carrying angle (CA), was made. The cubital axis was also measured clinically, and the range of motion and the patients subjective complaints were registered.

The duration of the follow-up ranged between 8 and 18 years, on average 12 years. The age of the patients at the follow-up was 12 to 26 years, average 18 years.

RESULTS

Primary results

The primary roentgenological results evaluated according to the criteria in Table 3 were good in 59 cases (55 per cent), fair in 44 cases (41 per cent) and poor in 4 cases (4 per cent) (Table 4). All of the seven fractures treated surgically healed without any com-

plications. Volkmann's contracture did not develop in any of the cases. A transient radial nerve injury was present in two patients (2 per cent). In four cases (4 per cent) roentgenological changes of myositis ossificans were seen, which later disappeared completely.

In our series there were vascular complications in four cases (4 per cent). Loss of pulse in the radial artery was found after the fracture reduction and surgery was performed immediately. In each of these four cases the brachial artery was found to be compressed between the fracture fragments. No

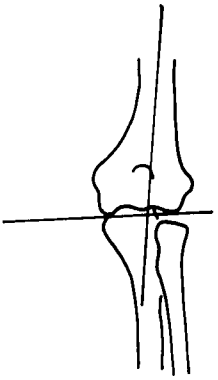


Figure 4A. Carrying angle.

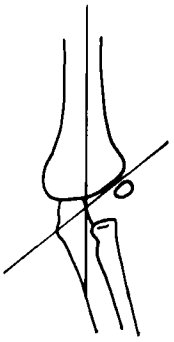


Figure 4B. Baumann's angle.

Table 2. Methods of treatment

Group	I	II	III	IV	V	Total
Immobilization with plaster splint	5	—	—	2	—	7
Closed reduction and plaster splint	3	4	4	11	13	35
Closed reduction and Dunlop traction	—	—	3	9	46	58
Open reduction osteosynthesis/traction	—	—	1	—	6	7
Total	8	4	8	22	65	107

Table 3. Criteria used in the evaluation of roentgenological results. Dislocation of the distal fragment

Result	Ad latum*) AP projection	Ad latum*) Lateral projection	Ad axim	Tilting	Rotation
Good	≦1/4	≦1/4	≦15°	≦ 5°	slight
Fair	≦1/2	≦1/2	≦20°	≦10°	moderate
Poor	>1/2	>1/2	>20°	>10°	severe

*) Displacement measured as part of the diameter of the bone.

Table 4. Primary roentgenological results

Group	I	II	III	IV	V	Total	Per cent
Good	7	4	3	15	30	59	55.0
Fair	1	—	5	6	32	44	41.3
Poor	—	—	—	1	3	4	3.7
Total	8	4	8	22	65	107	100.0

arteriotomy was performed because of return of good peripheral pulse. The recovery was uneventful and complete.

Late results

The roentgenological results at the follow-up study, evaluated according to the criteria listed in Table 3, were good in 87 cases (81 per cent), fair in 12 cases (11 per cent) and poor in 8 cases (8 per cent) (Table 5).

The primary and late results in the groups treated with plaster immobilization and those treated with traction and plaster immobilization are seen in Table 6. The late results do not differ significantly from the primary ones ($\chi^2 = 2.33 < \chi^2_5\% = 5.99$).

Clinically the varus/valgus deformity, i.e., the difference in the cubital angle on both sides, correlated with that of the roentgenological carrying angle. Restriction of extension by 5–10° was present in two cases, limitation of flexion by less than 10° in ten cases and between 10 and 20° in another four cases. Rotational movement was normal in all cases.

In the late follow-up study seven cases were classified as poor because of varus, and one case because of valgus angulation. The valgus angulation and two cases of varus amounted to 15°. None of these patients required any treatment. In five cases with 25° of varus, however, a corrective osteotomy was performed.

Comparison of primary and late results

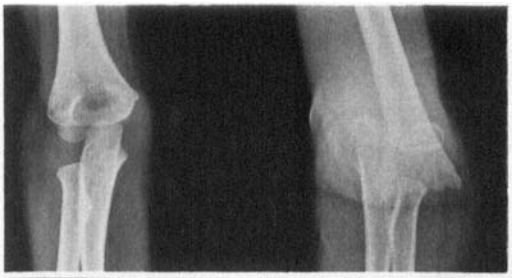
In comparing the results of the primary and late follow-up examinations, it is quite clear that rotation and displacement of the distal fragment in the frontal or sagittal plane, resulting in a primary classification of fair or poor, had disappeared at the time of follow-up. The only exceptions were three cases with tilting of the distal fragment, in two cases varus of 15°, and one case valgus of 15°. In the evaluation of the eight cases classified as poor at the follow-up compared with the four cases with this classification after the primary fracture treatment, we could see the following points of interest. Of these

Table 5. Late roentgenological results

Group	I	II	III	IV	V	Total	Per cent
Good	7	4	5	17	54	87	81.3
Fair	—	—	1	2	9	12	11.2
Poor	1	—	2	3	2	8	7.5
Total	8	4	8	22	65	107	100.0

Table 6. Comparison of the primary and late results in cases treated by closed reduction and plaster and reduction combined with skin traction.

Method	Primary result			Late result		
	Good	Fair	Poor	Good	Fair	Poor
Reduction and plaster (35 cases)	20	12	3	27	3	5
Reduction and skin traction (58 cases)	30	27	1	50	5	3
Total (93 cases)	50	39	4	77	8	8



A

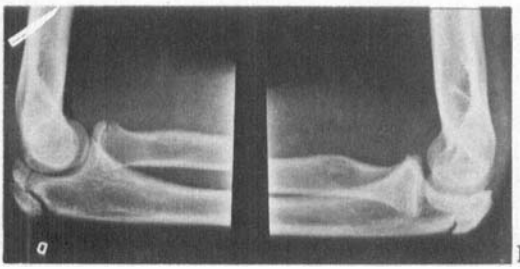
Figure 5. A and B. Severe posteromedial displaced fracture (Group V) in a 5-year-old-boy.

B

C

C. Five weeks after injury. The fracture was treated with Dunlop's skin traction and a plaster cast. The primary result is poor because of tilting of the distal fragment into varus of more than 20° and severe rotational deformity.

D



E

D and E. Ten years later. The rotational deformity has remodelled, but the result remains poor because of the varus deformity of 25°. A corrective osteotomy was performed later.

four initially poor cases two were also classified as poor at the follow-up because of a severe varus deformity of 25° (groups IV and V) (Figure 5). The severe fracture displacements with only slight varus deformity in the other two poor cases (group V) remodelled and could be classified as fair at the follow-up. Three cases were classified as poor at the follow-up because of a change in CA into varus (two cases) or valgus (one case) as discussed above. In three cases primarily classified as good in groups I, III and IV, with only slight rotational deformity, a fracture line through the medial epiphyseal plate resulted in a growth disturbance and a varus deformity and thus a poor end result.

DISCUSSION

Conservative treatment of supracondylar fractures of the humerus either by reduction and plaster immobilization or by reduction and Dunlop's skin traction seems to be a safe method giving good results. No significant difference between the results of these two methods was seen. There were no serious complications, and the slight skin lesions in some patients treated by Dunlop's skin traction disappeared during hospital treatment. In the past few years a posterior plaster splint has been used to prevent any displacement in the frontal plane and rotation (Gripenberg 1972). Because the swelling gradually disappears the position of the fragments must be carefully checked with repeated X-rays. Smith (1960, 1967), Mitchell & Adams (1961) and Dodge (1972) reported the development of a varus or valgus deformity of the CA in many cases treated by closed reduction and plaster. They favoured the traction method, as did Dunlop (1939), or skeletal lateral olecranon traction (Smith 1960) as the best way of treating severely displaced supracondylar fractures.

Poor end results have generally been reported in between 4–14 per cent of cases after conservative treatment (Siris 1939, Madsen 1955, El-Sharkawi & Fattah 1965, Henrikson 1966, Izadpanah 1973). In our series the end result was poor in eight cases (8 per cent), which is in full agreement with the results reported by other authors.

Results of open surgical treatment have not been good (Sandegård 1943, Holmberg 1945, Gruber & Hudson 1964). Alonso-Llames (1972) and Flynn et al. (1974) reported better results, with a varus tilting of the CA over 10° in only 7 and 12 per cent of the cases treated surgically.

Our results seem to show that even a gross dislocation, including rotation of the distal fragment, is remodelled by growth, if no tilting into varus or valgus occurs. This fact was first published by Baumann (1929), and confirmed by Smith (1960) in his experimental work. On the other hand we also found that primary tilting of the distal fragment does not remodel which is in accordance with the observations of Baumann (1929).

A growth disturbance occurs rarely (Baumann 1929, Attenborough 1953, Blount 1955, Smith 1960, Mann 1963, Hagen 1964); in our study in three cases (3 per cent). It only occurs if the fracture unilaterally injures the epiphyseal plate (Baumann 1929, Blount 1955).

The most severe complication of supracondylar fracture of the humerus is Volkmann's ischaemic contracture. Vascular and neural complications are generally reported in 3–22 per cent of cases (Siris 1939, Holmberg 1945, Lipscomb & Burleson 1955, Mitchell & Adams 1961, Hagen 1964, El-Sharkawi & Fattah 1965, Henrikson 1966, Hördegen 1970, Flynn et al. 1974, Fowles & Kassab 1974). The most frequent neural complication reported is injury to the radial nerve which also occurred in our series, but paralysis of the ulnar and median nerve may also occur. Paralysis of the anterior interosseous nerve may also occur in rare cases (Spinner & Schreiber 1969). Elström et al. (1975) and Rowell (1975) reported the rare interposition of the brachial artery and vein together with the median nerve at the fracture site between the fragments. The

absence of the peripheral pulse after fracture reduction is an indication for exploration. This happened in four cases in our series, and all were treated surgically with good results. We believe that open surgical treatment is indicated only in cases of vascular or neural injuries and when traction fails to maintain the correct reduction.

Conclusions

1. The majority of supracondylar fractures in children can be treated successfully with closed reduction and immobilization in a plaster cast.
2. Reduction combined with Dunlop's skin traction is a valuable and safe method for treating cases of severe posterior displacement.
3. If the change in the CA or Baumann's angle is 10° or more we recommend rereduction within 1 to 2 weeks.
4. Rotational deformity and displacement in the frontal or sagittal plane will remodel during growth. A tilting deformity into varus or valgus does not remodel.

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