Acta orthop. Scandinav. *XXXV*, 138–148, 1964.

From the Department of Surgery (Head: Knut Bie, M.D.), Haugesund sykehus, Haugesund, Norway. (Former Head: Kristian Stray, M.D., Professor of Surgery, University of Bergen.)

SKIN-TRACTION-TREATMENT OF SUPRACONDYLAR FRACTURES OF THE HUMERUS IN CHILDREN

A Ten-Year Review

By

ROLF HAGEN

Supracondylar fractures of the humerus are the most common elbow injuries in children. The treatment of these fractures, when badly displaced, remains a difficult fracture problem in childhood. Different closed reduction methods of treatment have been recommended (*Böhler* 1943, *Palmer* 1962, *Watson-Jones* 1960). However, some surgeons have advocated various forms of osteosynthesis, such as Rissler nails (*Holmberg* 1945, *Windfeld & Pilgaard* 1961) or Rush-pins (*Rastima & Korttila* 1960).

The treatment by permanent skin traction was originally recommended by *Bardenheuer* in 1889 (*Borchgrevink* 1908) with the elbow in right-angled position. *Borchgrevink* constructed a special splint and the traction was accomplished in the direction parallel with the normal forward tilt of the lower humeral epiphysis. *Ingebrigtsen* in 1908 intended to avoid the splint and advocated a modification of the skin traction in smaller children. In the bedridden patient the extremity is suspended overhaed by means of skin traction in three directions. Later the adhesive tape traction method in various forms has been recommended by other authors (*Dunlop* 1939, *Matti* 1931, *Siris* 1938).

The following study endeavours to evaluate the late results of two different conservative methods of treatment. One group of severely displaced fractures was treated with *Ingebrigtsen*'s skin traction, while another similar group of fractures was immobilized in a posterior plaster splint with a collar- and cuff sling, a method recommended by *Watson-Jones* and *Palmer*.

In both groups the reduction was performed under general anaesthesia with the forearm in pronation. Fluoroscopy through the mobile image amplifier was used only intermittently to verify the position of the fragments.

The overhead pulley adhesive suspension was applied as suggested by *Ingebrigtsen* (Fig. 1): Traction to the pronated forearm to keep the distal fragment in position (retention loads 1–3½ kg.), countertraction to the upper arm to pull the proximal fragment posteriorly (loads ½–1 kg.) and vertical traction parallel with the longitudinal axis of the upper arm (½–3 kg.), depending on the degree of dislocation, the obliquity of the fracture line, and the age of the child. The average flexion degree of the elbow was 40° (range 25°–70°). The skin traction was continued for an average of 21 days, whereas the duration of immobilization of the posterior plaster splint cases averaged 28 days.

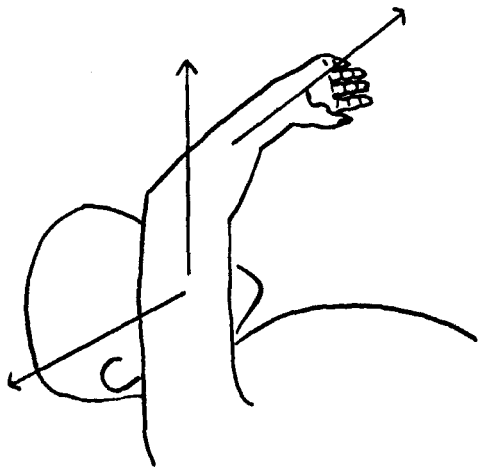

Fig. 1.
Ingebrigtsen's skin traction.

THE SERIES

During the period 1951–1960, in all 70 patients with supracondylar fractures were admitted to the Department. 60 per cent of the fractures were in boys and 40 per cent in girls. 78 per cent were between the ages of 3 and 10 years, the average age was 6 years (range 1–14).

For purposes of comparison with other series, the fractures have been classified into 4 types according to the degree of displacement detected on roentgen examination, a system originally suggested by *Holmberg* (Table 1).

TABLE 1
Types of Fractures.

		No.	♂	♀	Ext. type	Flex type
Type I	Fractures without displacement	4	2	2	...	...
Type II	Fractures with sideways and/or dorsal (ventral) displacement ...	16	11	5	16	...
Type III	Fractures with rotational displacement, possibly with sideways and angulatory displacem.	17	5	12	12	5
Type IV	Fractures with complete displacement (no contact between the fragments)	33	24	9	31	2
	Total number of fractures	70	42	28	59	7

5 of the extension type fractures belonging to Type IV were compound, and 1 of the Type III fractures was a comminuted Y-fracture. Type III and Type IV combined (severely displaced fractures) made up 70 per cent of the total number of fractures. The displacement of the distal fragment in the four different types is given in Table 2.

TABLE 2
Displacement of the Distal Fragment.

	Rotational displacement			Side-displacement with or without angulation		
	Inwards	Outwards	None	Radial	Ulnar	None
Type I	...	...	...	...	...	...
Type II	...	...	...	8	...	8
Type III	12	5	...	10	5	2
Type IV	26	5	2	17	16	...

TREATMENT

The treatment applied in the four different types is shown in Table 3. The flexion type fractures were treated as follows: 4 by skin traction in 25° of elbow flexion and 3 by a posterior plaster splint with the elbow acutely flexed.

In general, the fractures treated by skin traction were more severe than those treated in the acute-angled elbow position. The former group included 5 compound fractures and two thirds of the fractures with an

oblique fracture line in lateral view. Manipulative reduction had to be repeated once in 16 patients and twice in 3 patients belonging to Type III and IV. Secondary displacement occurred in 26 per cent of the cases, mainly among the posterior plaster splint cases. In 10 patients treated by skin traction, manipulative reduction and a plaster cast or a posterior plaster splint were tried primarily without success. Minor displacements persisting after the primary reduction disappear as a rule during 10–12 days with sustained skin traction, by which time roentgenograms usually show callus. The average age incidence in the skin traction group was 6.4 years (range 2–13), and in the posterior plaster splint group 6.1 years (range 1–11).

TABLE 3
Method of Treatment in the Four Different Types of Fractures.

	Type I	Type II	Type III	Type IV	Total
Manipulative reduction and skin traction ...	...	...	8	18	26
Manipulative reduction, posterior plaster splint and sling (elbow acute-angled)	4	16	9	15	44
Total	4	16	17	33	70

The primary results; *i.e.* the results at the end of the treatment judged from the roentgenograms, were graded into the following groups as presented in Table 4.

TABLE 4
Primary Results.

		Perfect anatomical or slight sideways displacement		Sideways and slight rotational displacement	Rotational and angulatory displacement	Total
Skin traction	Type III	3	61.5 %	5	...	8
	Type IV	13		4	1	18
Posterior plaster splint	Type I	4		...	...	4
	Type II	13		3	...	16
	Type III	4	58.3 %	3	2	9
	Type IV	10		2	3	15
Total		47		17	6	70

COMPLICATIONS

Judged from the literature, complications appear to be relatively common (*Böhler, Lipscomb & Burleson* 1955, *Watson-Jones*).

In the present study there was an incidence of 17 per cent of neural and vascular injuries. The radial nerve was injured in 8 cases, the median nerve in 2 cases and the ulnar nerve in 1 case. They commonly occurred among Type IV extension fractures. The injury of the ulnar nerve was encountered in a Type III flexion fracture. 6 of the cases recovered completely during the hospitalization, whereas the remaining 5 nerve injuries disappeared during 2–6 months.

The radial pulse was absent in 7 cases. All of these were treated by *Ingebrigtsen*'s skin traction and the radial pulse returned after the reposition. Voelkmann's ischaemic contracture has not developed in any of the cases.

FOLLOW-UP STUDIES

All the 70 patients were re-examined clinically and roentgenologically from 2 to 11 years after the fracture, the average observation time being 6.5 years. Changes in the normal carrying-angle were observed in 23 (32.9 per cent) of the 70 patients examined (Table 5). A varus-type change was nearly twice as frequent as increased valgidity. The change in carrying-angle occurred in 34 per cent of those treated by skin traction, and in 58 per cent of an equivalent group treated by acute-angled elbow position. Perfect anatomical results were achieved in 67 per cent of the whole material.

TABLE 5

Changes in Normal Carrying Angle at Follow-up.

	No change	Reduced	Increased	Total	Degree of angle	
					Max	Average
Skin traction	17	6	3	26	10	6.6
Posterior plaster splint	30	9	5	44	30	8.5
Total	47	15	8	70		

FINAL RESULTS

On clinical follow-up, the state of the injured elbow was classified according to the criteria originally applied by *Holmberg:*

1. *Satisfactory Results.*

a) Ideal: No complaints, varus or valgus deformity of 0–5°, normal range of motion.

b) Good: Varus or valgus deformity of 6–10°, limitation of flexion-extension of 0–10° and no impairment in rotation.

2. *Unsatisfactory Results.*

Changes surpassing these limits.

The final results are listed in Table 6. *All the 26 skin traction cases presented a satisfactory result,* while an equivalent group of 24 patients treated by a posterior plaster splint showed 3 unsatisfactory results. One of these cases was almost ideally reduced on admittance; however, the patient was dismissed on the second day after reduction and a severe secondary ulnar tilt of the distal fragment occurred. In a second case the fracture was apparently combined with severe capsular and ligamentous damage and healed with marked volar and ulnar angulatory displacement. Lastly, an extension fracture of a 3 year old boy was obviously not properly reduced and healed with rotational and angulatory displacement. In the flexion fractures 6 had ideal and 1 a good result.

TABLE 6
Final Results.

Type	Treatment	Satisfactory		Unsatisfactory	Total
		Ideal	Good		
I and II	Posterior plaster splint	20	...	...	20
III	Skin traction	7	1	...	8
	Posterior plaster splint	5	3	1	9
IV	Skin traction	15	3	...	18
	Posterior plaster splint	12	1	2	15
Total		59	8	3	70

COMMENT

Table 7 gives an impression of the relation between the adequacy of the reduction and the end result.

A persistent sideways or slight rotational displacement causes little or no loss in the carrying-angle. On the other hand, an angulatory

displacement will inevitably produce such a change. It is notable that in none of these cases was a valgus or varus angulation corrected by remodelling, not even in the ealier mentioned case of the 3 year old boy. *Smith* (1960) showed experimentally by a transverse supracondylar osteotomy that only varus or valgus angulation changed the carrying-angle. This did not occur with sideways displacement or with an internal rotation of less than 15° of the distal fragment. However, any degree of rotation with an oblique fracture line in the lateral view will produce tilting of the distal fragment. *Mann* (1963) analysed 22 children with severe supracondylar fractures and concluded that cubitus varus deformity was caused by medial angulation of the distal fragment.

TABLE 7
Relation between Primary and Final Results.

Primary results		Final results		
		Ideal	Good	Unsatisfactory
Ideal or almost ideal	47	47	...	...
Sideways and slight rotational displacement	17	12	5	...
Rotational and angulatory displacement	6	...	3	3
Total	70	59	8	3

Osteosynthesis or a traction arrangement prevents this tendency to angulatory displacement. However, most authors admit that operative procedure may be technically difficult and is often followed by decreased range of movement and some residual stiffness. *Höyer* (1952) reported good results in his series treated by skeletal traction on a Semb's abduction splint. Meanwhile, several surgeons warn against the use of skeletal wire traction in the immediate proximity of the elbow joint. Such a procedure is uncomfortable and also unnecessary because the needed amount of traction to compensate the forces of redislocation is comparatively small. Skin traction of the acute-angled elbow position is in this respect sufficient.

Concerning the treatment *ad modum* Ingebrigtsen, it should be stressed that the elastic adhesive tape, properly applied, will not compromise the neurovascular structures in the front of the elbow joint. This is advantageous for treating badly displaced fractures with considerable swelling. Furthermore, the patient can actively exercise the elbow within the confines of the dressing during the period of immobi-

lization. The absorption of haematoma and synovial exudate is stimulated and the tendency to stiffness of the elbow and muscular atrophy is prevented. The return of function is thus hastened, and the functional late results seem favourable.

The results obtained in the present series among Type III and IV fractures have been compared with *Holmberg*'s operatively treated group and *Höyer*'s group treated by skeletal traction (Table 8). The indications for the various methods of treatment have in all probability been the same. In comparing these groups, it is evident that *Ingebrigtsen*'s method discloses a higher percentage of superior results.

TABLE 8

Comparisons between the Final Results of Osteosynthesis, Skeletal and Skin Traction and Treatment a. m. Watson-Jones.

	Satisfactory		Unsatisfactory	Total
	Ideal	Good		
Osteosynthesis (Holmberg)	28	14	8	50
Skeletal traction (Höyer)	14	10	2	26
Skin traction (Hagen)	22	4	...	26
Acute-angled elbow flexion (Hagen)	17	4	3	24

SUMMARY AND CONCLUSION

70 children with supracondylar fractures of the humerus were reexamined at an interval from 2 to 11 years after the injury. Severely displaced fractures constituted 70 per cent of the whole material, and were mainly treated by acute-angled elbow flexion and skin traction.

As a rule, the fragments separated by a transverse fracture line extending along the boundary between cartilage and bone are easily reduced and retained by acutely flexed elbow. The triceps tendon keeps the distal fragment in position, the fracture surfaces are broad and the tendency to secondary displacement is small.

In some cases, however, this treatment does not suffice. Those separated by an oblique fracture line at a higher level in the olecranon fossa are frequently more difficult to reduce and often slip during the postreduction period. These fractures require skin traction as their primary definitive treatment. In all compound and comminuted fractures and in cases with vascular complications, skin traction is the treatment of choice.

Growth disturbance as a cause of change in the carrying-angle was not suggested in any of the cases. From this material the prime reason for these changes seems to be disalignment of the fragments.

Ingebrigtsen's skin traction method was followed by minimal loss of function and the smallest percentage of carrying-angle changes. This method of management has proved practical and has a successful effect on the pathological process following a supracondylar fracture.

RESUME

70 enfants avec fractures supracondylaires de l'humérus ont été réexaminés au bout d'une période entre 2 et 11 ans après la lésion. Des fractures graves avec déplacement constituaient 70 pour cent de l'ensemble du matériel d'observation et avaient principalement été traités par flexion du coude à angle aigu et traction de la peau.

En règle générale, les fragments séparés par une fracture transversale longeant la ligne de démarcation entre le cartilage et l'os sont plus faciles à réduire et à maintenir en place dans la position de flexion du coude à angle aigu. Le tendon du triceps maintient le fragment distal en place, les surfaces de la fracture sont larges et la tendance au déplacement secondaire est faible.

Dans certains cas, cependant, ce traitement n'est pas suffisant. Lorsque les fragments sont séparés par une fracture de ligne oblique à un niveau plus élevé de la fosse oléocrânienne, la réduction est souvent difficile et les fragments se séparent parfois pendant la période de post-réduction. Ces fractures exigent une traction de la peau comme traitement primaire définitif. Dans toutes les fractures compliquées et broyées et dans les cas avec complications vasculaires, la traction de la peau est le traitement de choix.

Des troubles de la croissance comme une cause des modifications de l'angle du coude n'ont été présumés dans aucun de ces cas. La cause primordiale des changements semble être un désalignement des fragments.

La méthode de traction de la peau d'Ingebrigtsen a été suivie avec une perte fonctionnelle minime et le pourcentage le moins élevé de modifications de l'angle du coude. Cette méthode s'est montrée pratique et a eu un heureux effet sur le processus pathologique consécutif à une fracture supracondylaire.

ZUSAMMENFASSUNG

70 Kinder mit suprakondylären Humerusbrüchen wurden nach einem Zeitraum von 2 bis 11 Jahren nach der Verletzung wiederuntersucht. Hochgradig verschobene Brüche machten 70 Prozent des Gesamtmateriales aus und wurden hauptsächlich mittels Hautextension bei spitzwinkelig gebeugtem Ellbogen behandelt.

In der Regel können die Fragmente, welche durch eine transverse Bruchlinie gesondert sind die sich entlang der Grenze zwischen Knorpel und Knochen ausdehnt, leicht reponiert und bei spitzwinkelig gebeugtem Ellbogen in Stellung gehalten werden. Die Tricepssehne hält das distale Fragment in Stellung, die Bruchflächen sind weit und die Neigung zur sekundären Verschiebung ist gering.

In einigen Fällen jedoch genügt diese Behandlung nicht. Jene, die durch eine schräge Bruchlinie, etwas länger proximal in der fossa olecrani getrennt sind, sind oft schwieriger zu reponieren und gleiten oftmals sekundär. Diese Brüche erfordern Hautextension als primäre und endgültige Behandlung. Bei allen komplizierten und Splitterbrüchen ist die Hautextension die Methode der Wahl. Wachstumsstörung als Ursache einer Veränderung des Achsenwinkels war in keinem der Fälle angedeutet. Aus diesem Material geht hervor, dass der vorherrschende Grund für derlei Veränderungen eine schlechte Anpassung der Bruchstücke war.

Ingebrigtsens Hautextensionsmethode hatte einen sehr kleinen Funktionsverlust und den geringsten Prozensatz von Veränderungen des Achsenwinkels zur Folge. Diese Behandlungsmethode hat sich als praktisch erwiesen und hat eine erfolgreiche Wirkung auf den einer suprakondylären Fraktur folgenden pathologischen Prozess.

REFERENCES

Bardenheuer, B.: Die permanente Extensionsbehandlung. Stuttgart, 1889 (Referred to by Borchgrevink).

Borchgrevink, O.: Ambulatorische Extensionsbehandlung der oberen Extremität. Von Gustav Fischer, Jena, 1908.

Böhler, L.: Die Technik der Knochenbruchbehandlung. Maudrich, Vienna, 1943.

Dunlop, J.: Transcondylar fractures of the humerus in childhood. J. Bone Jt Surg. *21*: 59–73, 1939.

Holmberg, L.: Fractures in the distal end of the humerus in children. Acta chir. Scandinav. Suppl. 103, 1945.

Höyer, A.: Treatment of supracondylar fracture of the humerus by skeletal traction in an abduction splint. J. Bone Jt Surg. *34–A*: 623–637, 1952.

Ingebrigtsen, R.: Personal communication, 1962.

Lipscomb, P. R. & Burleson, R. J.: Vascular and neural complications in supracondylar fractures of the humerus in children. J. Bone Jt Surg. *37–A*: 487–492, 1955.

Mann, T. S.: Prognosis in supracondylar fractures. J. Bone Jt Surg. *45–B*: 516–522, 1963.

Matti, H.: Zur Behandlung der suprakondylären Humerusfraktur. Chirurg. *2*: 41–50, 1937.

Palmer, I.: Nordisk Lærebog i Kirurgi. Munksgaard, Copenhagen, pp. 810–813, 1962.

Rastima, R. O. & Korttila, K.: Rush-pin vid distala humerusfrakturer. Nord. Med. *63*: 653–655, 1960.

Siris, I. E.: Supracondylar fracture of the humerus. An analysis of 330 cases. Surg. Gynec. Obstet. *68*: 201–222, 1938.

Smith, L.: Deformity following supracondylar fractures of the humerus. J. Bone Jt Surg. *42–A*: 235–252, 1960.

Watson-Jones, R.: Fractures and joint injuries. Livingstone, Edinburgh and London, pp. 524–532, 1960.

Windfeld, P. & Pilgaard, S.: Osteosyntese af suprakondylære humerusfrakturer hos børn. Nord. Med. *66*: 1266–1268, 1961.