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COLLES' FRACTURE TREATED WITH MODIFIED BÖHLER TECHNIQUE

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In Scandinavia, immobilisation of the wrist in a functional position according to Böhler's principle has hitherto been the prevailing treatment of Colles' fracture. According to this principle, the wrist is bandaged in an intermediate position between volar and dorsal flexion combined with ulnar deviation. The aim is mild volar flexion in the radio-carpal joint by using dorsal pressure on the wet plaster. Mild dorsal flexion is induced at the same time in the carpo-metacarpal joint while retaining the hand and fingers in line with the long axis of the forearm. The forearm adopts an intermediate position between supination and pronation (Böhler 1953). A number of reports have been published on treatment results in Scandinavia according to this method (Nissen-Lie 1939, Höjensgaard 1945, Rosen 1947, Madsen 1949, Wiklund & Müllern-Aspegren 1956, Hölund 1957). The strictness with which Böhler's principle was applied is not apparent in all studies. A more neutral position of the wrist has been advocated in later papers (Lidström 1959, Frykman 1967).

After Madsen's (1949) observations there was a tendency in this country to replace the original, short forearm plaster with a high, encircling plaster cast so as to prevent the pronounced tendency to redislocation. However, subsequent studies concerning the guidelines laid down by Madsen failed to show correspondingly good results (Hölund 1957). Moreover, since the large cast has been associated with certain drawbacks, we attempted immobilisation with a short forearm cast and sought to achieve the most suitable position for the wrist according to experimental and clinical experience reported in the literature (Mayer 1940, Böhler 1953, Mandell 1965). The method differs from Böhler's with pronounced ulnar flexion of the wrist and pronation of the forearm. As preliminary reports showed promising results

(Kaalund Jensen et al. 1967) a prospective study was planned. The results of this investigation are presented in the following.

PRESENT INVESTIGATION

The series comprises 92 consecutive casualty ward patients (17 men and 75 women) with 93 fractures from January 1967 to September 1968. Only Colles' fractures with dislocation were included in the study. Lidström's (1959) classification of Colles' fractures was used in order to achieve a differentiated evaluation of the method's usefulness with varying degrees of fracture instability.

Types II A to II E were included. Fracture of the styloid process of the ulna was noted in 63 per cent of the cases.

II A: Extra-articular fracture with moderate dorsal displacement.
II B: Intra-articular non-comminuted fracture with moderate dorsal displacement.
II C: Extra-articular fracture with total displacement.
II D: Intra-articular non-comminuted fracture with total displacement.
II E: Intra-articular comminuted fracture with total displacement.

The types of fracture in relation to age and sex are presented in Table 1. Most fractures were ascribed to falls.

METHOD

All patients were treated with immediate reduction of the fracture under local infiltration anaesthesia a.m. Böhler. Blockade of a fracture of the styloid process of the ulna was of importance in eliminating pain reactions during the procedure.

Reduction of the fracture was undertaken in two stages: (1) Disimpaction of the fracture fragments with thumb, second and third finger traction, the forearm pronated and the elbow in right-angle flexion. (2) While maintaining traction, a padded dorsal plaster splint, 12 or 15 cm wide, was applied and fixed with an elastic bandage from the knuckles to the plica cubiti. Reduction and manipulation of the fracture in the wet plaster then followed, using dorsal pressure with the thenar eminence over the distal fragment, which was simultaneously supported by the other hand's vola on the hallow side. The

Table 1. Age and sex distribution in 93 Colles' fractures. The types of fracture are in accordance with Lidström's (1959) classification.

Types of fracture	15–19 years		20–29 years		30–39 years		40–49 years		50–59 years		60–69 years		70–79 years		80–89 years		Number of fractures
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	
II A	1	1	3	3			2	4	2	10		13	1	3		2	45
II B							1			7		5		2			15
II C								1		2		3		2			8
II D			1				1		2	3		1		2		1	11
II E			1				1	1	1	3		1		6			14
Total	2		8		0		11		30		23		16		3		93

injured wrist was herewith immobilised with appropiate ulnar deviation, i.e. so that the root of the thumb aligned with the forearm's radial limitation. The wrist was slightly flexed and the forearm severely pronated. The cast covered both the ulnar and the radial aspect of the forearm with the thumb left free.

The following day the patient returned for a bandage check and instructions were given in energetic, active exercises for the fingers, elbow and shoulder. Radiographic examination of the fracture was undertaken before and after reduction and once a week for a further 4 weeks, using frontal and profile projections. A sling was only used the first few days.

After 4 weeks in plaster, the cast was removed and the patient began exercises under the guidance of the casualty doctor or, if necessary, at a physical therapy clinic until satisfactory results had been achieved (Table 2).

Twelve to eighteen months after the fracture trauma, 85 of the 93 fractures were given a follow-up examination by the authors, and radiographs were taken of both wrists. One of the 8 patients not checked had died and the remainder did not wish to participate.

In order to evaluate the method's suitability for more extensive use, the present series was divided into two equally large groups of similar composition with respect to the severity of the fracture. One group was treated by the authors and the other in the casualty ward by the doctor who happened to be on duty at the time of the accident. The doctors in question, who were all experienced surgeons, were all employed in the Department of Orthopaedic Surgery and carefully instructed in the procedure.

RESULTS

Incidence of Ideal Reductions

In accordance with Lidström, we chose as criteria for ideal reduction a volar angle* of $\leq 90°$, a ≤ 2 mm shortening † as compared to the healthy side and perfect apposition between the radial and volar

* In profile projection a line is drawn through the middle of the radial diaphysis and from the anterior to the posterior edge of the distal radial articular surface. The angle is measured between the proximal and volar parts of these two lines.

† The difference in distance between two parallel lines drawn perpendicular to the axis through the radial diaphysis on a level with the tip of the styloid process of the radius and lower joint surface on the capitulum ulnae on the healthy and injured sides.

Table 2. Physical therapy was given to 82 fractures. The period is indicated.

Period of physical therapy	< 1 week	1–2 weeks	3–4 weeks	5–6 weeks	> 6 weeks
Number of fractures	17	31	19	6	9

Table 3. Number of cases in which requirements for perfect reduction were satisfied in the different groups of fracture types.

Type of fracture	II A	II B	II C	II D	II E	Total
Perfect reduction	38/45	13/15	3/8	9/11	8/14	71/93
Per cent	85			60		76

cortical surfaces with 1 mm as the largest acceptable gap. Evaluated in this manner, ideal reductions were achieved in 71/93 fractures (76 per cent). See Table 3. In the group treated by the authors, ideal reduction was found in 81 per cent of the cases, and in 71 per cent of the cases treated by "others". Additional manipulative reduction was undertaken with 5 patients.

Redislocation in the Radio-carpal Joint

Redislocation required a displacement of the volar angle by at least 10° and/or a shortening by ≥ 4 mm. Fourteen such cases were seen in the series (15 per cent), four in the 1st week, six in the 3rd week, two in the 4th week and two after 4 weeks. 10/14 fractures belonged to groups II C, II D and II E. 9/14 fractures redislocated after ideal reduction. The redislocation was a dorsal dipping in three cases, radial shortening only in nine cases, and a combination of the two in two cases. Rereduction was not performed, as the volar angle exceeded 100° only by a few degrees in 2 elderly women. The frequency of redislocation was about the same in the group treated by the authors and in the group treated by "others".

Early Complications

Only a few sequelae were associated with treatment. In ten the plaster had to be corrected and/or the bandage loosened the day after

Table 4. Anatomical end results (I–IV degrees) in 84 fractures in relation to comminution of the fracture and to the functional end results. One patient had a new fracture and is excluded from the table.

Anatomical end results		Types of fracture					Per cent	Functional end results			
		II A	II B	II C	II D	II E		Excellent	Good	Fair	Poor
I	No deformity	33/41	10/14	2/7	5/10	4/12	64	45	7	2	–
II	Slight deformity	6/41	3/14	3/7	4/10	5/12	25	7	11	2	1
III	Moderate deformity	2/41	1/14	2/7	1/10	3/12	11	3	2	4	–
IV	Severe deformity	–	–	–	–	–		–	–	–	–
	Per cent							65	24	10	1

reduction. Two developed paraesthesia, one median and ulnar and one in the ulnar area. The paraesthesia disappeared in both cases once the plaster was removed (for further comments, see the section on late results). Four women, one of them the patient with median and ulnar paraesthesia, developed post-traumatic reflex dystrophy.

Infection as the result of the administration of an inter-fragmental Böhler block was not seen. There were no pressure necroses as a result of manipulation of the fracture in wet plaster.

Anatomical and Functional End Results (Table 4)

Evaluation of the anatomical end results was based on Lidström's classification from I to IV degrees.

Degree I : *Volar angle $\leq 90°$. *Shortening < 3 mm.
Degree II : Volar angle 91–100° and/or 3–6 mm shortening.
Degree III: Volar angle 101–114° and/or 7–11 mm shortening.
Degree IV: Volar angle $\geq 115°$ and/ or > 12 mm shortening.

Functional end results were evaluated on the basis of the patients' subjective complaints and objective findings (Lidström 1959, Frykman 1967).

* See previous footnote.

Table 5. Incidence of sequelae in 85 fractures at follow up.

Type of fracture	Sequelae										
	Pain in wrist on loading and non-loading	Tingling pain in innervation field of the median nerve and/or the ulnar nerve	Loss of strength	Loss of finger-mobility	Loss of mobility in wrist Volar/dorsiflexion 5–15° reduced	Loss of mobility in wrist Volar/dorsiflexion 15–30° reduced	Loss of < 1/3 of normal rotation	Radial deviation	Prominence of capitulum ulnae	Silver-fork deformity	Roentgenological signs of post-traumatic arthritis of radiocarpal and/or distal radio-ulnar joint
II A	3/41	1/41	5/41	–	1/41	–	1/41	3/41	2/41	–	2/41
II B	3/14	1/14	3/14	–	2/14	1/14	2/14	1/14	3/14	–	2/14
II C	–	–	1/7	–	–	–	–	3/7	–	–	–
II D	2/10	–	2/10	–	2/10	–	–	1/10	3/10	–	2/10
II E	3/13	1/13	4/13	–	2/13	1/13	3/13	2/13	5/13	–	7/13
Total	11	3	15	0	7	2	6	10	13	0	13

1. Excellent: Unrestricted wrist function. No subjective complaints or visible deformity. Limitation in volar and dorsal flexion not to exceed 15°. No loss of strength.
2. Good: Unrestricted wrist function. Minor subjective complaints. Deformity can be accepted if subjective complaints are not associated herewith. Movement limitation up to 20° and mild loss of strength.
3. Fair: Less satisfactory wrist function when working with a load or upon extreme movement. Function otherwise retained. Moderate loss of strength.
4. Poor: Reduced work capacity and impaired general capacity. Cases with constant pain. Significant loss of strength.

Table 4 discloses a relative predominance of union in less than ideal positions among severely dislocated and comminuted fractures. Good functional results were seen in almost all cases of union in an anatomically correct position. However, very poor positions did not preclude good final results.

Late Results

Table 5 provides the most important sequelae occurring in the study. Only individual groups will be discussed.

Gross neurological examination of three patients disclosed effects of nerve damage. Two who had developed ulnar paraesthesia during the bandaging had acquired hypaesthesia in the area. Mild paraesthesia in median area without motor loss was found in two patients, one of whom also had ulnar hypaesthesia.

Loss of strength was also registered in accordance with the principles of Lidström (1959) and Frykman (1967). Strength in the injured leading hand was considered reduced if strength was less than in the non-leading hand. Strength in the non-leading hand was considered reduced if its strength was less than half of that in the uninjured leading hand.

At follow-up 13 patients displayed unilateral radiological osteoarthrosis in the injured wrist, three in the radio-carpal joint, five in the distal radio-ulnar joint, and five in both joints. In all cases, the fractures were intraarticular in the joint in question with the exception of two cases with osteoarthrosis in the radio-carpal joint where the fracture line could not be followed through the joint surface. Radiographic changes comprised manifest sclerosis of joint surfaces, sub-

Table 6. 31 fractures with post-traumatic displacement in the distal radio-ulnar joint. The difference of disalignment in the distal radio-ulnar joint of the injured and the non-injured wrist in relation to radial shortening is indicated in the different groups of functional end results.

Post-traumatic displacement in the distal radio-ulnar joint indicated as the difference of disalignment in the joint of the injured and non-injured wrist	Functional end results								
	Excellent			Good			Fair		
	Radial shortening								
	< 3 mm	3–6	7–11	< 3 mm	3–6	7–11	< 3 mm	3–6	7–11
+ 1 – – + 3 mm	●● ●● ●● ●● ●	●● ●●	●	●	●● ●●		●		
≥ + 3 mm			●		●● ●●	●		●●	●● ●

chondral clearing, and the formation of osteophytes. Cases with non-ideally reduced fractures and fractures with redislocation made up a large part of the group. Functional end results were surprisingly good: 5 excellent, 5 good and 3 fair.

Displacement in the Distal Radio-ulnar Joint

Displacement was found in 31 cases (37 per cent) at the follow-up. Displacement is an indication of secondary shortening of the radius and is measured as the difference of disalignment in the distal radio-ulnar joint in frontal radiographs between the injured and non-injured wrist. There was a ≥ + 3 mm displacement in 11 (Table 6). There was good correlation between the degree of displacement in the distal radio-ulnar joint, incorrect positioning after fracture union and functional results.

Socio-economic Status

Since most patients with Colles' fracture are elderly, this type of fracture is not of great interest from the insurance point of view. 13/92 patients bothered to send in notices to the insurance office.

At the follow-up examination, 75/84 patients had unimpaired work-

ing capacity, 8 had mild and 1 had severely impaired working capacity. Two had to give up their previous occupations: one was a 62-year old woman who had done heavy cleaning work, and a 24-year old diabetic instrument maker.

DISCUSSION

Previous reports on the treatment of Colles' fracture and the results of the present study confirm that union in a less than ideal position contributes significantly to impairment of functional results. Assuming correct anatomical reduction, the usefulness of a method, therefore, depends on the related incidence of secondary dislocation of fragments.

The unstable Colles' fracture is a typical compression fracture with radial and dorsal compression of the spongiosa. Exact reduction leaves these areas with a spongiosa defect, which is why accurate radial and volar apposition of intact cortical bone should be aimed at in an effort to stabilise the fracture. The dorsal cortical bone is often shattered and therefore of little service for retention of the corrected fracture. Under these circumstances, immobilisation without the use of internal fixation is difficult to achieve without the development of redislocation.

With a view to the greatest possible stability after correction, we feel that careful and gentle reduction, preferably at the first attempt, and modelling of the fragments are of the greatest importance. Immobilisation with the forearm in pronation is recommended to correct the "supination twist" of the distal fragment as described by Mayer (1940). Ulnar flexion is used to counteract radial dipping, whereas the degree of volar flexion appears to be incapable of influencing the re-dislocation tendency (Sirbu & Collof 1951, Gartland & Werley 1951) and should, therefore, only be induced the few degrees necessary to create careful volar apposition.

With an ideal reduction incidence of 76 per cent when using the above principles, we achieved stable immobilisation with a redislocation incidence of 15 per cent for the entire material. Taking groups II C to E separately, 30 per cent redislocated. Mandell's material (1965), treated according to the same principles as ours, had redislocation in 20 per cent of the cases without any indication of the degree. Lidström's series, comprising 478 checked cases treated with a short dorsal slab with the wrist in a neutral position, displayed a

28 per cent incidence of redislocation for the entire material and 40 per cent for groups II C to E. Redislocation occurred with Madsen (1949) in 59 per cent of the cases treated with forearm plaster and in 11 per cent of the cases immobilised by high, encircling plaster with the wrist in Böhler's position. In Hölund's series (1957), 40 per cent of all fractures treated with a high, encircling plaster with the hand immobilised according to Böhler's principle redislocated. The materials are not directly comparable, as the criteria given by the latter two authors for redislocation are not exactly the same as those given by Lidström (1959) and the present authors. However, even taking this into consideration, we feel our immobilisation principle with Colles' fracture had considerable bearing on the low incidence of redislocation.

In our opinion, extension of the plaster to the upper arm provides no added advantage in view of the varying reports of redislocation when using this form of bandaging with the same fracture types and principles of treatment (Madsen 1949, Hölund 1957). Furthermore, an angled plaster may restrict mobilising shoulder movements (Hölund 1957), which is important in order to avoid the "shoulder-hand-finger" syndrome (Frykman 1967).

Lidström (1959) and Frykman (1967) found that approximately 50 per cent of their patients with distal fractures of the radius had subjective sequelae at the follow-up, 20–25 per cent of them so severe that the results had to be reported as unsatisfactory. This was the case in approximately 11 per cent of our patients one year after their accidents. In this connection, the high frequency of ideal reduction and low incidence of redislocation should not be reported without mention including the intensive physical therapy given during and after bandaging.

Previous reports show that a disalignment, triggered by trauma, in the distal radio-ulnar joint beyond the normal variation of ± 3 mm (Lang 1942) is often associated with pain conditions of long duration (Lang 1942, Kiaer 1949). In our material, ten patients were found with significant redislocation in the distal radio-ulnar joint, resulting in a disalignment of more than ± 3 mm. Three of the patients had wrist pain, particularly on twisting motion, and seven had reduced strength 12–18 months after the fracture. This number of patients with persistent pain in conjunction with level displacement in the distal radio-ulnar joint was relatively smaller than that reported by Kiaer (1949), whose patients were only observed for three months.

It seems that these sequelae tend to disappear with an extended period of observation.

According to Lidström (1959) and Frykman (1967), radial shortening combined with level displacement in the distal radio-ulnar joint is an important factor in the genesis of patients' subjective complaints about the injured wrist, with corresponding impairment of functional results. Table 6 confirms this observation, as there is an increase in cases with relative extension of the ulna in relation to pronounced radial shortening and declining functional results. Thus, the relative extension of the ulna appears to be of value in assessing functional results, even if results are not unequivocal (Table 6).

The occurrence of post-traumatic arthritis, which cannot be distinguished radiographically from degenerative osteoarthrosis, is well-known in conjunction with traumatic joint injury (Abrams 1966). Radiographic evidence may appear within 3–6 months after the triggering trauma (Abrams 1966). The development of post-traumatic arthritis in the radio-carpal joint and distal radio-ulnar joint is reported in the literature with varying frequency and time intervals (Frykman 1967). Our findings of 13 cases with this sequela, radiographically evaluated as mild, may suggest that this condition develops more frequently than previously believed. The unilateral localisation with development after adequate trauma supports the notion of a traumatic genesis.

SUMMARY

A prospective study of the unstable Colles' fracture treated according to modified Böhler principle is presented. A total of 92 out-patients comprising 93 consecutive, dislocated Colles' fractures were treated.

The technique is described in detail and its suitability is discussed with reference to redislocation in the radio-carpal joint and displacement in the distal radio-ulnar joint during and after immobilisation. Anatomical and functional end results were evaluated 12–18 months after the injury. Union in an ideal position and good functional results occurred in 64 per cent and 89 per cent respectively, of the cases. The late results were evaluated on the basis of subjective and objective findings.

The authors state that the method can be used to advantage in the treatment of the unstable Colles' fracture if the enumerated principles are adhered to.

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