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Classification of distal radius fractures

We analysed retrospectively a series of 269 distal radius fractures in adults in order to determine which of five different classification systems gave the best information about the radiographical prognosis of a fracture. The result after reduction in 195 cases was influenced mainly by the primary shortening, whereas dorsal angulation, radial displacement, and the age and sex of the patient were of minor importance. The system described by Older et al. in 1965, was superior to the others. In the analysis of the radiographical result after fracture union, the quality of the reduction, the Older classification system, and the age of the patient were the most important prognostic factors. We conclude that reduction of a distal radius fracture should primarily aim at correcting the shortening.

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The results of treatment of a distal radius fracture are difficult to compare because different classification systems have been applied. I have addressed the following questions:

1) Do commonly used classifications furnish prognostic information as regards stability of acceptable reduction?

2) To what extent do age, sex, primary displacement, degree of joint involvement and comminution determine the quality of the reduction and the position of the fracture at union?

Patients and methods

All patients above 20 years of age with distal radius fractures within 4 cm of the articular surface, treated in 1979–1981, were subjected to a retrospective analysis. Fractures with volar angulation (Smith's fractures) were excluded. Only patients with adequate radiographs were included. This reduced the number of patients from 457 to 269, including 41 men with a median age of 58 (20–85) years and 228 women with a median age of 64 (26–101) years.

In 195 cases, the reduction was performed in local anaesthesia with manual traction, followed by immobilization with dorsal and volar splints with the hand in slight pronation, volar flexion and ulnar deviation. The cast was not changed until removal after 5–6 weeks. In 74 cases, where no reduction was performed, a dorsal splint was used for 5 weeks. In 15 patients secondary dislocation required re-reduction or internal fixation.

The radiographs before reduction, after reduction, and at fracture union were evaluated for dorsal angulation, shortening (the distance between the tip of the radial styloid and the base of the ulnar styloid), and radial displacement (Solgaard 1984).

All fractures were classified according to Nissen-Lie (1939), Gartland & Werley (1951), Lidström (1959), Older et al. (1965) and Frykman (1967) (Figure 1).

The results after reduction and at fracture union were defined as anatomical, provided there was no occurrence of dorsal angulation and that the radial styloid was at least 7 mm long. Furthermore, radial displacement of maximally 1 mm was allowed. Radial deviation (angulation) was not recorded, as this implies no further information than the shortening (Van der Linden & Ericson 1981, Solgaard 1984).

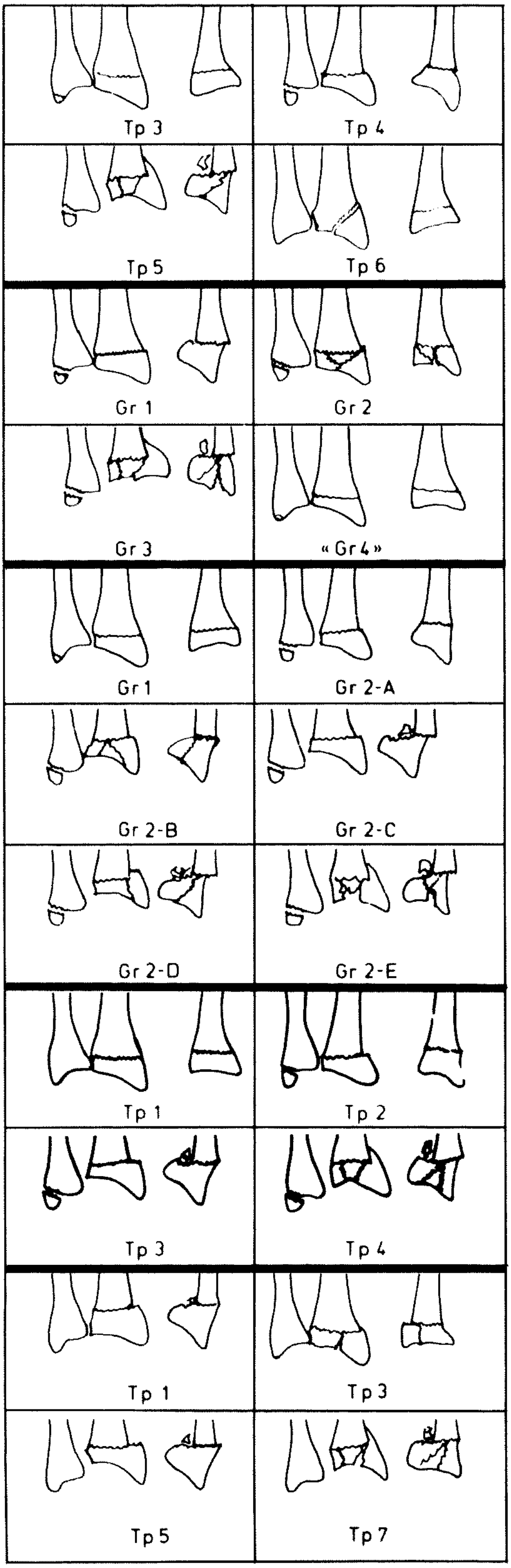
Statistical analysis

The statistical analysis implied the use of a multivariate log-linear regression model (Bishop et al. 1975). A preliminary base-model for the data was formulated based on the results of the analyses of 2- and 3-dimensional marginal tables.

Thereafter the data were subjected to specific analyses to evaluate the results implied by the results of the explorative analysis of marginal tables, with the emphasis on determining whether the interaction between variables could be characterized as direct or indirect.

When investigating the results at fracture union (269 patients), the result of the reduction was included in the analysis. In 15 cases with secondary dislocation and re-reduction, the radiograph before the new reduction was recorded as the result at union.

Chi-square and Goodman-Kruskall's gamma tests were used to evaluate the associations between variables.



A. *Nissen-Lie (1939).* Four fracture types with no grading of the displacement. Type 3: Minimal displacement; Type 4: Dorsal angulation, extra-articular, no comminution; Type 5: Intra-articular, comminuted; Type 6: Fractures of the radial styloid.

B. *Gartland & Werley (1951).* Three fracture types with no grading of the displacement. Group 1: Extra-articular, displaced; Group 2: Intra-articular, no displacement; Group 3: Intra-articular, displaced. To include all fractures in the present material, a fourth type, Group 4, of non-displaced extra-articular fractures was added.

C. *Lidström (1959).* Six fracture types. Group 1: Minimal displacement; Group 2-A: Extra-articular, dorsal angulation; Group 2-B: Intra-articular, dorsal angulation, joint surface not comminuted; Group 2-C: Extra-articular, dorsal angulation and dorsal displacement; Group 2-D: Intra-articular, dorsal angulation and displacement, joint surface not comminuted; Group 2-E: Intra-articular, dorsal angulation and displacement, joint surface comminuted.

D. *Older et al. (1965).* Four fracture types. Type 1: Dorsal angulation up to five degrees, radial length distal to ulna at least 7 mm; Type 2: Dorsal angulation, radial length 1 to 7 mm, no comminution; Type 3: Dorsal radius comminuted, radial length less than 4 mm, distal fragment slightly comminuted; Type 4: Marked comminution, radial length usually negative.

E. *Frykman (1967).* Eight fracture types. Type 1: Extra-articular; Type 2: As Type 1 with fracture of the distal ulna; Type 3: Radio-carpal joint involved; Type 4: As Type 3 with fracture of the distal ulna; Type 5: Distal radio-ulnar joint involved; Type 6: As Type 5 with fracture of the distal ulna; Type 7: Radio-carpal and distal radio-ulnar joints both involved; Type 8: As Type 7 with fracture of the distal ulna.

Figure 1. Schematic drawings of the five classification systems investigated.

Results

Results of reduction

The initial dorsal angulation of the fracture influenced the result of reduction (Table 1), but only indirectly due to the fact that when shortening increased, this was often followed by an increase in dorsal angulation, but after stratification and calculation of partial gamma values, it was established that only the shortening was of importance ($P < 0.00001$).

Age and sex were without importance for the quality of reduction.

The evaluation of the five classification systems showed that Older's system was superior to the others ($P < 0.0005$). Nissen-Lie's and Lidström's classifications were next in ranking ($P < 0.015$).

Less than 30 per cent of the most severely displaced fractures of Type 3 and Type 4 could be reduced anatomically (Table 2). Most Type 2 fractures had also required reduction, and in 47 per cent of these an anatomical position was achieved.

Results at fracture union

The initial exploratory analysis showed that all parameters except the sex of the patient influenced the end-result (Table 1). The result at fracture union was independent of the need for reduction in initially displaced fractures or primary anatomical position in non-reduced fractures; only the quality of reduction was of importance ($P < 0.00005$).

The screening indicated that the second most important factor determining the result at fracture union was the fracture type according to Older et al. (1965) ($P < 0.0005$). All classification systems, however, apparently had prognostic value. To elucidate this further, the results were stratified according to Older's system, and partial gamma values were calculated (Table 1). Apart from Frykman's, the other systems lost their importance when Older's system was included, and when the age of the patient and the result of reduction were also included, the importance of Frykman's classification was eliminated. Thus the prognostic value of the other four classification systems was less than that of Older's system.

Table 1. The result of the statistical screening in distal radius fractures as indicated by Goodman-Kruskall's marginal gamma values. Partial gamma values are the result of stratification according to Older's classification (see text for further explanation)

	Anatomical reduction	Anatomical position at fracture union	
	Marginal gamma	Marginal gamma	Partial gamma
Dorsal angulation	0.190*	0.710***	0.04
Radial displacement	0.240*	0.465***	0.18
Shortening	0.450***	0.657***	0.24
Age	0.013	0.443***	0.50***
Sex	0.003	0.359	
Nissen-Lie	0.309*	0.427**	0.03
Gartland & Werley	0.136	0.710***	0.36
Lidström	0.351*	0.734***	0.03
Older et al.	0.417***	0.852***	–
Frykman	0.007	0.276**	–0.418*
Anatomical reduction	–	0.881***	0.775***

a. $*P \le 0.05$, $**P \le 0.01$, $***P \le 0.001$.

Only one of 106 Type 3 and Type 4 fractures was in anatomical position at fracture union, although 30 fractures had been reduced to ideal position (Table 2).

Age was the third most important factor for the result at fracture union ($P < 0.002$). The younger the patient, the better the prognosis, and the influence of age was not reflected in the result of reduction; even if reduction was perfect, older patients still had a worse prognosis.

None of the other parameters recorded carried any valuable prognostic information, and the significance of the initial displacement (dorsal angulation, radial displacement and shortening) was only reflected indirectly through the influence on the quality of the reduction.

Table 2. The radiographical results after reduction and at fracture union in 269 patients with distal radius fractures, classified according to Older et al. (1965)

Fracture type	Number of reduced fractures	Anatomical reduction	Anatomical union	Total
1	4	4	26	51
2	85	40	13	107
3	88	26	0	92
4	18	4	1	19
Total	195	105	40	269

Discussion

Successful treatment of distal radius fractures implies the solution of two major problems: satisfactory reduction and retention of the fracture until union. This investigation indicates that the most important factor for a good radiographic result at fracture union is the quality of the reduction. The result of the reduction was directly influenced by the initial shortening, whereas dorsal angulation only had indirect importance through its association with shortening. A similar relationship between shortening and dorsal angulation was found by Van der Linden & Ericson (1981), but they considered dorsal angulation to be more important.

The evaluation of the classifications confirmed the analysis of the initial displacement. The system described by Older et al. (1965) had the greatest prognostic value, probably because its keystone is the shortening.

An anatomical reduction was mandatory for an anatomical position at fracture union, but secondary dislocation often occurred. The analysis established that this risk of secondary displacement was described best if the fracture was classified according to the system described by Older et al. (1965). This classification, apart from the shortening, also takes into account the dorsal comminution, which probably was responsible for the secondary dislocation seen in most Type 3 and 4 fractures. The prognosis worsened as the age of the patient increased, probably due to the weak, dorsal cortex, responsible for the secondary dislocation.

The other classification systems also had value, but only if Older's system was excluded from the analysis. Stratification of the results according to Older's system eliminated the prognostic value of the other systems which are mostly based on the location of the fracture lines (intra- or extra-articular) without quantitation of the displacement or shortening.

We evaluated only the factors determining the radiographic result after reduction and at fracture union. The influence of the primary displacement and the fracture type on the functional result has not been clarified by this study. Previous studies, however, have demonstrated that a good radiographical end-result correlates with a good clinical result. The present study indicates that to improve the position of the fracture at union, effort should primarily be directed towards reducing the shortening of the fracture.

The classification introduced by Older et al. (1965) proved to be the best of the five analysed classifications. It implies valuable information in respect of the possibility of achieving both anatomical reduction and anatomical position at fracture union. Its wider use would facilitate the comparison of different treatments of wrist fractures.

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