

# Patients with laxity of the distal radioulnar joint after distal radial fractures have impaired function, but no loss of strength

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Submitted 00-03-20. Accepted 01-07-10

**ABSTRACT – Laxity of the distal radioulnar (DRU) joint after distal radial fractures has a worse general outcome in patients before the usual age for development of osteoporosis. The hypothesis for this study was that patients with laxity also have less strength during supination and pronation. An apparatus for measuring strength in supination and pronation was constructed and validated. 20 patients were chosen from a cohort of 76 patients who had had distal radial fractures 6 years ago. The stability of the DRU-joint was tested manually by 2 examiners and the test's reliability was good. The DRU-joint was lax in 6 patients. No differences were found between patients with stable and lax DRU-joints as regards isometric grip strength, strength in supination or pronation or radiographic characteristics. However, subjectively evaluated hand function was impaired in those with lax DRU-joints. This was noted on the subjective part of the Gartland and Werley score and 13 questions concerning everyday activities. In conclusion, DRU-joint laxity was associated with impaired hand function, but no loss of strength in forearm rotation after distal radial fractures in non-osteoporotic patients.**

Measurements of grip strength and range of motion, as well as radiographs, do not necessarily correlate with outcome in these patients (Lindau et al. 2000b). Since the DRU-joint is of major importance in pronation and supination, we thought that patients with a lax DRU-joint would have less isometric strength during pronation and supination and that this might be detected with objective measurements reflecting clinical outcome. The first aim of this study was to evaluate an apparatus for measuring the isometric strength in supination and pronation in healthy subjects. The second aim was to assess the reliability of the clinical stability test of the DRU-joint. The third aim was to determine whether stability influenced isometric strength during pronation or supination in patients who had sustained distal radial fractures 6 years ago. The fourth aim was to correlate DRU-joint stability with subjective outcome, using questions concerning everyday activities.

## Reliability test of the apparatus

### *Patients and methods*

We constructed an apparatus with an adjustable handle and a torque meter to measure isometric strength during supination and pronation (Figure 1). The handle could be set in 10°–20°–30°–40°–50° of ulnar deviation towards the longitudinal axis of the forearm. The shoulder was placed in zero position with the arm held to the body with the elbow at 90° flexion and the forearm held in position by soft padding for the ulnar aspect of the

The importance of distal radioulnar (DRU) joint laxity after distal radial fractures is not well understood. We have shown that laxity of the DRU-joint worsens the outcome of distal radial fractures in patients before the usual age for development of osteoporosis, independently of the radiographic findings (Lindau et al. 2000b). The subjective part of the Gartland and Werley wrist score (Gartland and Werley 1951, Sarmiento et al. 1975) differs between patients with stable and lax DRU-

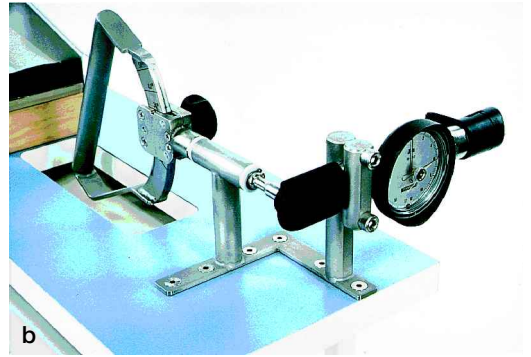
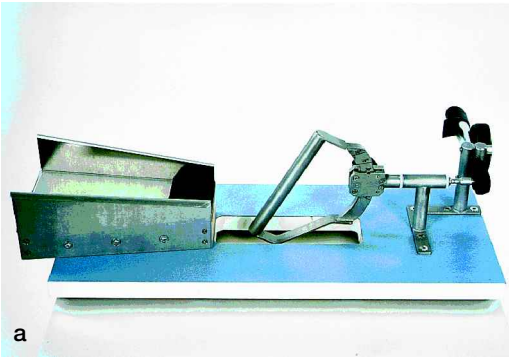


Figure 1.

- The constructed apparatus with an adjustable handle ( $10^{\circ}$ – $20^{\circ}$ – $30^{\circ}$ – $40^{\circ}$ – $50^{\circ}$  of ulnar deviation) and a torque meter.
- Close-up of the torque meter.
- The patient holds the shoulder in zero position with the arm held close to the body at  $90^{\circ}$  flexion of the elbow and the forearm held in position by soft padding for the ulnar aspect of the wrist.

wrist. To assess the reliability of the apparatus, we examined 10 healthy volunteers (5 women) having a median age of 33 (20–44) years, and no history of injury to the upper extremity. We made measurements in two sessions at an interval of at least 1 week (tests I and II). 5 settings of ulnar deviation of the handle were tested in all cases. At each angle, the measurement included 3 during supination (first the nondominant hand, then the dominant hand) followed by pronation. Thus, “test I” here refers to the mean value of 3 measurements in the first session. The first angle with which the measurement was started was changed by  $10^{\circ}$  between each volunteer. Grip strength was measured with a Jamar dynamometer, before and after measuring supination and pronation. The measurement error (95% confidence interval) was calculated for each angle ( $1.96 \times SD \times (\text{test I} - \text{test II}) / \text{test I} \times \sqrt{2}$ ). Calculations were also made regarding fatigue ((first measurement – last measurement) / first measurement and (Jamar before – Jamar after) / Jamar before).

### Results

We found no major difference as regards measure-

ment error between the various angles in the measurement of strength during supination and pronation (Table 1). On the basis of these results, we chose the  $30^{\circ}$  angle for the clinical evaluation.

No fatigue was noted. During the prono-supination sessions, minor changes occurred—e.g., at the  $30^{\circ}$  angles, where supination with the dominant hand showed a median (range) 0% (–23–7%) loss

**Table 1.** The measurement errors of each handle position in determination of strength during supination and pronation. The measurement error (95% confidence interval) was calculated using  $1.96 \times SD \times (\text{test I} - \text{test II}) / \text{test I} \times \sqrt{2}$ . The table shows that the 95% confidence interval of a single measurement is about 20–25% of the measured value

Angle	Supination		Pronation	
	Dom.	Nondom.	Dom.	Nondom.
$10^{\circ}$	0.25	0.32	0.17	0.18
$20^{\circ}$	0.25	0.26	0.21	0.22
$30^{\circ}$	0.19	0.33	0.22	0.21
$40^{\circ}$	0.18	0.21	0.15	0.17
$50^{\circ}$	0.17	0.22	0.18	0.17

Dom. dominant hand. Nondom. nondominant hand.

Table 2. Clinical findings in patients with laxity of the DRU-joint, evaluated by the 2 blinded examiners

Examiner 2	Examiner 1 (TL)	
	Lax	Stable
Lax	5	2
Stable	1	12
Total	6	14

of strength during movement and  $-4\%$  ( $-25$ – $11\%$ ) loss during pronation. In the entire series of measurements, the loss of grip strength in the dominant hand was median (range)  $0\%$  ( $-18$ – $8\%$ ) and  $1\%$  ( $-18$ – $7\%$ ) in the nondominant hand.

## Clinical evaluation

### Patients and methods

On the basis of a power analysis, we selected 20 patients (12 women) having a median age of 40 (20–56) years at the time of fracture from a cohort of 76 patients, who had been followed for 2 years after the injury (Lindau 2000b). 1 patient was primarily treated with surgery (in the stable group) and 1 patient was treated with closed reduction and plaster whose redislocation required treatment with external fixation (in the lax group). No patient was treated for malunion or some other late complication. The clinical evaluation was done mean 5.6 (4.8–6) years after the trauma. Measurements of dorsal angulation, ulnar variance, radial length and radial angulation (Table 5) were made on radiographs at the time of fracture, and classified according to Arbeitsgemeinschaft für die Osteosynthese (AO, Müller et al. 1990), and those at the 2-year follow-up.

The measurements of strength during supination and pronation were done as described above, with the handle at  $30^\circ$  of ulnar deviation in all patients. The stability of the DRU-joint was tested by the first examiner (TL) and then by a second one (PA) in a different room. The first examiner had previously examined such patients (Lindau et al. 2000a, b), but the second examiner had not done this test before. The findings of the first examiner (TL) were therefore used to diagnose patients as stable or lax for the comparisons between the two groups. The

Table 3. The strength of grip, supination and pronation in relation to the healthy contralateral hand, percentages

Measured strength	Stable (n 14)	Lax (n 6)	Difference with (95% confid. interval)
Grip	97	87	10 ( $-1$ – $21$ )
Supination	95	91	4 ( $-7$ – $15$ )
Pronation	89	95	$-6$ ( $-17$ – $5$ )

examiners had no knowledge about the patients—e.g., medical charts or radiographs, and the patients were asked not to give any clinical information until later. The stability of the DRU-joint was tested with the forearm in neutral position. Both examiners tried to force the radius manually in dorsal and palmar directions versus the ulna. Laxity relative to the contralateral side was recorded.

Finally, the patients were asked to evaluate pain on load (VAS, visual analogue scale; 0–100 mm), the subjective evaluation of hand function using the modified Gartland & Werley wrist score (GW-score; Gartland and Werley 1951, Sarmiento et al. 1975; 0, 2, 4 or 6p, where 6p is worst). The patients answered a questionnaire that was sent to their homes, concerning their ability to perform 13 everyday activities (1–5 on a scale, where 5 is worst, Table 6). The scale for each question was divided (dichotomised) between good (= 0) and bad (= 1) by an ergotherapist, who was not involved in the study. This was done to minimize the influence of differences in the scales between various questions. The questions were designed for this study and not further validated, but numbers 4, 7, 9, 10 and 11 relate to DRU-joint problems (Table 6).

Comparisons between stable and lax joints were evaluated with nonparametric tests. The inter-rater agreement for the laxity test was calculated as the kappa-value, with the 90% confidence interval (Altman 1991).

## Results

The first examiner (TL) found laxity in the DRU-joint in 6 patients. The agreement between the 2 examiners as regards the clinical stability test of the DRU-joint was 17/20 (Table 2). However,

Table 4. The subjective evaluation of pain on load (visual analogue scale, VAS; 0–100 mm), overall hand function (subjective Gartland & Werley score) and 13 questions concerning discomfort while performing everyday activities (each question answered by 1–5 on a scale where 5 is worst) in patients with stable or lax DRU-joints. Median and p-values calculated with the Mann-Whitney U-test

Subjective evaluation	Stable (n 14)	Lax (n 6)	P-value
Pain on load (VAS)	4	10	0.2
Overall hand function (subj. GW-score)	0	3	0.04
Sum of all 13 questions	15	25	0.02
Sum of dichotomized answers to the 13 questions	0.5	5	0.03

the inter-rater agreement is better described with a kappa-value of 0.66 (CI 90%; 0.36–0.95), which is rated as good (Altman 1991).

Laxity of the DRU-joint was not associated with reduced strength of grip, supination or pronation (Table 3). There was no statistically significant difference in the VAS assessment of pain on load (Table 4). Patients with stable or lax DRU-joints were radiographically similar, both as regards degree of initial dislocation, fracture type and comminution as well as the final result on the 2-year follow-up (Table 5).

The subjective evaluation of hand function was lower in patients with lax DRU-joints, as measured with the subjective part of the Gartland and Werley wrist score ( $p = 0.04$ ; Table 4), according to the sum of all 13 questions concerning everyday activities ( $p = 0.02$ ; Tables 4 and 6) and according to the

dichotomized answers ( $p = 0.03$ , Table 4). However, the 5 questions that we thought were specific for the DRU-joint were not worse in patients with lax DRU-joints ( $p = 0.1$ ). Although the 13 questions concerning the performance of every-day activities distinguished between stable and lax cases, and strength did not, there was a correlation between the total sum on the questionnaire and grip strength ( $r^2 = 0.43$ ), but the strength during supination showed a poorer correlation ( $r^2 = 0.28$ ) and the pronation showed hardly any correlation at all ( $r^2 = 0.03$ ).

## Discussion

Laxity of the DRU-joint foreshadows a worse outcome after distal radial fractures in patients without

Table 5. Differences in radiographs between patients with stable and lax DRU-joints at the time of fracture and the 2-year follow-up, median (range)

Radiographic parameters	Stable (n 14)	Lax (n 6)
<i>At the time of fracture</i>		
Dorsal angulation (°)	–3 (–22–32)	18 (–18–31)
Ulnar variance (mm)	0 (–1–3)	0 (0–2)
Radial length (mm)	12 (8–14)	9 (5–12)
Radial angulation (°)	23 (17–27)	21 (10–25)
Intra-articular fracture	6	2
Comminution	2	1
<i>At the 2-year follow-up</i>		
Dorsal angulation (°)	0 (–15–15)	11 (–14–18)
Ulnar variance (mm)	0 (–1–4)	0 (0–2)
Radial length (mm)	10 (7–12)	12 (8–15)
Radial angulation (°)	21 (17–27)	22 (12–24)

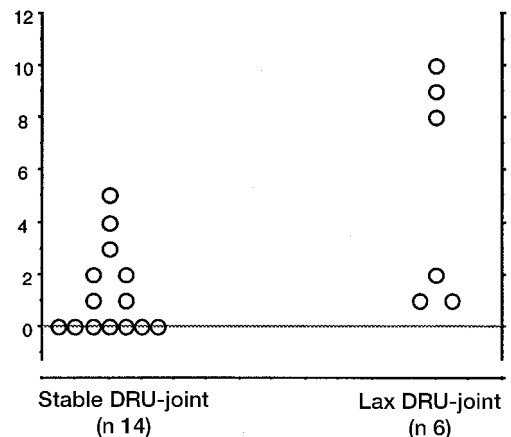


Figure 2. Comparison of the sum of the dichotomized answers as regards performance of activities in daily living by patients with stable and lax DRU-joints.

Table 6. Distribution of answers to questions concerning discomfort while performing everyday activities by patients with stable or lax DRU-joints (1-5 on a scale where 5 is worst). The questions are listed according to the results with the questions giving the largest difference between the groups first and then in descending order

	Stable (n 14)					Lax (n 6)				
	1	2	3	4	5	1	2	3	4	5
1. Lifting a heavy suitcase (from the floor to a chair)	9	4	0	1	0	0	2	3	1	0
2. Carrying a heavy shopping-bag	8	5	0	1	0	0	2	3	1	0
3. Brushing your teeth	14	0	0	0	0	3	2	0	1	0
4. Turning on/off a tap (faucet) <sup>a</sup>	14	0	0	0	0	3	2	0	1	0
5. Pressing down on a door handle	13	1	0	0	0	3	2	1	0	0
6. Pouring milk from a carton	14	0	0	0	0	4	1	1	0	0
7. Using a screwdriver <sup>a</sup>	12	2	0	0	0	3	1	2	0	0
8. Tying shoe laces (or similar knots)	12	2	0	0	0	3	2	1	0	0
9. Turning a stiff key <sup>a</sup>	9	3	0	2	0	2	1	2	0	1
10. Opening a screw-top jar <sup>a</sup>	9	3	1	1	0	2	1	1	1	1
11. Wringing out a dishcloth <sup>a</sup>	10	3	0	1	0	2	3	0	1	0
12. Writing with a pen	12	2	0	0	0	4	1	1	0	0
13. Washing your hair	13	1	0	0	0	5	1	0	0	0
Sum of all 13 questions	149	26	1	6	0	34	21	15	6	2

<sup>a</sup> Questions regarded as specific for the DRU-joint.

osteoporosis independently of radiographic signs of worse fractures (Lindau et al. 2000a, b). However, the difference between patients with stable and lax DRU-joints can not be measured with objective parameters, such as grip strength (Lindau et al. 2000a, b). We have now also found that strength during forearm rotation, as measured with our apparatus, was not affected by laxity. The 95% confidence intervals of the measurements exclude any clinically relevant difference in strength (Table 3).

The lack of a difference was unexpected, considering the pivotal role of the DRU-joint during this movement. In the test, when the patient was firmly gripping the handle, the DRU-joint may have been stabilized by secondary muscle-dependent stabilizers, such as the extensor carpi ulnaris tendon (Garcia-Elias 1998), the pronator quadratus muscle (Johnson and Shrewsbury 1976) and the radioulnar interosseous membrane (Hotchkiss et al. 1989). However, patients with laxity of the DRU-joint complained of worse subjective hand function in everyday situations (Tables 4 and 6). In such situations the wrist is probably not always stabilized by the secondary muscle-dependent stabilizers. Thus sudden movements can cause subluxation, with ensuing subjective problems. This is analogous to findings in patients with ruptures of the anterior cruciate ligament, who complain of a give-away

sensation in situations where sudden movements are not counteracted by adequate muscle tone. This underlines the importance of evaluating clinical end-results by combining traditional objective parameters with patient-related outcome questionnaires (Amadio et al. 1996).

In the present study, we showed that the inter-rater agreement of the clinical stability test of the DRU-joint was good, even with an untrained examiner (Table 2). Although the latter was totally blinded, the experienced one had seen the patients 4 years before. We admit that this is a bias as regards inter-rater agreement. However, it does not affect the other comparisons, because we were assessing relations with true laxity. If one examiner was more likely to make a correct diagnosis, this would only improve the analysis of relations between stability and symptoms or strength.

The inter-rater agreement was reassuring, because we know that clinically diagnosed laxity is associated with a worse outcome (Lindau et al. 2000a, b). The next problem is to correlate laxity with pathoanatomical changes, such as ligament ruptures. In a previous study, we found that arthroscopy-verified complete peripheral tears in the triangular fibrocartilage complex (TFCC) cause laxity of the DRU-joint (Lindau et al. 2000a). In that study, laxity was found in 10 of 11 patients with complete TFCC-

tears (Lindau et al. 2000a). Of the 40 patients without complete tears, 9 had lax DRU-joints, of whom 6 had had partial peripheral TFCC-tears (Lindau et al. 2000a). This means that every other patient with a lax DRU-joint had a complete peripheral TFCC-tear (sensitivity 0.53 (10/19)), and 4/5 of patients with lax DRU-joints a partial or complete peripheral TFCC-tear. Clinical stability of a DRU-joint means that the patient almost certainly has not had a complete tear (specificity 0.97 (31/32)). More importantly, almost all patients with a complete peripheral TFCC-tear associated with a distal radial fracture will develop laxity of the DRU-joint and have a worse outcome (positive predictive value 0.91 (10/11)). Therefore, we consider the laxity test useful and acceptable as compared to many clinical tests in orthopedic and hand surgery practice (Katz and Fingerroth 1986, Marx et al. 1999).

We were unable to design specific DRU-joint questions in the questionnaire concerning performance of everyday activities. We thought that in line with our view regarding the constructed apparatus, that the 5 questions reflecting rotational activities (Table 6) would be associated with a worse outcome in patients with lax DRU-joints. However, the sum of these specific DRU-joint questions was not worse in the lax group, only the sum of all 13 questions and the dichotomized answers. This again shows that DRU-joint stability is needed for many hand functions and that it may be futile to try to isolate specific DRU-joint-dependent situations.

As regards the four aims of the study, we conclude first, that the constructed apparatus was reasonably reliable as a tool (Table 1). Secondly, the clinical DRU-joint stability test produced relevant information (Table 2). Third, stability of the DRU-joint had no effect on the strength in forearm rotation (Table 3). Fourth, patients with laxity of the DRU-joint had impaired hand function as judged by questions concerning subjective evaluation (Tables 4 and 6).

This study was supported by grants from Stiftelsen för bistånd åt Vanföra i Skåne, the Medical Faculty of Lund University, the Gorthon foundations, the Gunnar Svanteson Memory Foundation and the Swedish Medical Research Council (project 2031). We thank Helene Nordquist for the ergotherapeutic aspects in the questionnaire.

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