



Paradoxical wrist flexion: A new test to detect functional weakness of the upper limb

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ABSTRACT

Background: Positive signs are essential for the diagnosis of functional neurological disorders (FND). The author described a new positive sign to diagnose functional weakness (FW), “paradoxical wrist flexion”, and tested its validity.

Methods: The test comprised Medical Research Council (MRC) examinations of wrist flexion in two different limb positions, one with the wrist maximally flexed (wrist flexion in the flexed position; WFfl) and the other with the wrist in the neutral position (wrist flexion in the extended position; WFex). In “organic” weakness (OW), WFfl should be stronger than WFex according to the dynamic theory. Paradoxical wrist flexion was judged positive when the MRC score for WFfl was lower than that for WFex. A higher MRC score for WFfl than WFex was considered an “organic sign” for wrist flexion. We retrospectively enrolled patients with FND or other “organic” neurological disorders, who presented with wrist flexor weakness with an MRC score of 4.

Results: Twenty-four patients with FW and 40 patients with OW were enrolled. Paradoxical wrist flexion was positive in 16 patients with FW and in no patients with OW, i.e. 67% sensitivity and 100% specificity. The “organic sign” for wrist flexion was positive in no patients with FW and in 35 patients with OW, i.e. 88% sensitivity and 100% specificity.

Conclusions: Paradoxical wrist flexion is useful for the detection of nonorganic paresis. The background theory is that an active movement is more severely affected in FW than a passive movement when maintaining a limb position.

1. Introduction¹

Neurological signs, i.e. “positive signs”, are essential clues for the diagnosis of functional neurological disorders (FND) [1–3]. Functional weakness is one of the major manifestations of FND, for which many positive signs have been described [2,3]. However, new positive signs are always of interest as their addition increases the probability of correctly diagnosing FND. For more than ten years the author has used a simple sign to discriminate between “organic” (the term “organic” has been criticized [4], but I continue to use it with quotation marks in this paper, as in other articles [2,5], since there is no better alternative term) and functional weakness of the upper-limb, named “paradoxical wrist flexion”. In this study, I retrospectively documented the validity of this sign.

2. Methods

2.1. MRC examination techniques

To examine paradoxical wrist flexion, the examiner evaluates the MRC score for wrist flexion at two different limb positions (Fig. 1 upper part). The patient is in a sitting position with the elbow flexed at an angle of 90° or slightly greater. First, the forearm is supinated and the wrist joint is maximally flexed, i.e. the hand is maximally lifted up. The patient is asked to make a tight fist so that they can exert maximal force. The examiner exerts force to extend the wrist of the patient, i.e. presses down the hand. This technique is named the test of wrist flexion in the flexed position (WFfl). Next, the forearm is pronated and the wrist joint is kept in the neutral position. The examiner uses force to extend the wrist of the patient, i.e. lifts up the hand. This technique is named the test of wrist flexion in the extended position (WFex) although this is

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¹ Abbreviations: FND, functional neurological disorders; FW, functional weakness; OW, “organic” weakness; WE, wrist extension; WFex, wrist flexion in the extended position; WFfl, wrist flexion in the flexed position.

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actually a neutral position.

The MRC score was graded by the standard method [6], although a modified scale for muscles that are free from the effect of gravity [7] was used since this was used even for foot dorsiflexion in a standard textbook [6]. Grade 3 or lower was difficult to judge in the WFex position, and in such cases a neutral (regarding pronation/supination) forearm position was used for evaluation. These points are not of great relevance since the MRC scores of 5 and 4 are mainly pertinent in this study.

We judged that paradoxical wrist flexion was positive when the MRC score for WFfl was lower than that for WFex, and interpreted this as a positive sign of functional weakness. A higher MRC score for WFfl than WFex was considered to be an “organic sign” for wrist flexion, suggesting a definite “organic” nature of the weakness. The underlying principle is explained in the discussion.

One recommendation when documenting paradoxical wrist flexion is to separate the examinations of WFfl and WFex in time by interposing MRC examinations of other muscles, especially in patients with FND. I usually conduct WFfl first, then evaluate the wrist extension (WE), extensor digitorum, and possibly intrinsic hand muscles and digit flexors, and lastly examine WFex. By doing so, the patient is less likely to recognize that the same muscles are examined by the WFfl and WFex tests.

2.2. Subjects

Subjects were enrolled from the author’s out-patient and EMG database in 2019. The patients having diagnoses of FND or other “organic” neurological disorders that may cause upper-limb weakness were extracted and their clinical and EMG records were reviewed. The extraction was performed for the whole of 2019 for the FND group, but only from January to June of 2019 for the OND group. The author has observed the usefulness of the paradoxical wrist flexion sign for more than 10 years, and has routinely conducted WFfl and WFex tests in the MRC examination of wrist flexion unless it was extremely weak, i.e. a score of 3 or lower on the MRC scale. The inclusion criteria were: 1) A final diagnosis was established as either FND or a certain “organic” neurological disorder, the latter by appropriate ancillary tests; 2) The record was the first evaluation by the author; 3) The MRC scores of the patient were evaluated by the author; 4) Separate tests of WFfl and WFex were conducted; 5) Either, or both, of WFfl or WFex had a score on the MRC scale of 4 in the weaker limb. Patients presenting with weakness due to FND were classified as the “functional weakness (FW)” group, whereas those presenting with weakness due to other “organic” neurological disorders were classified as the “organic weakness (OW)” group.

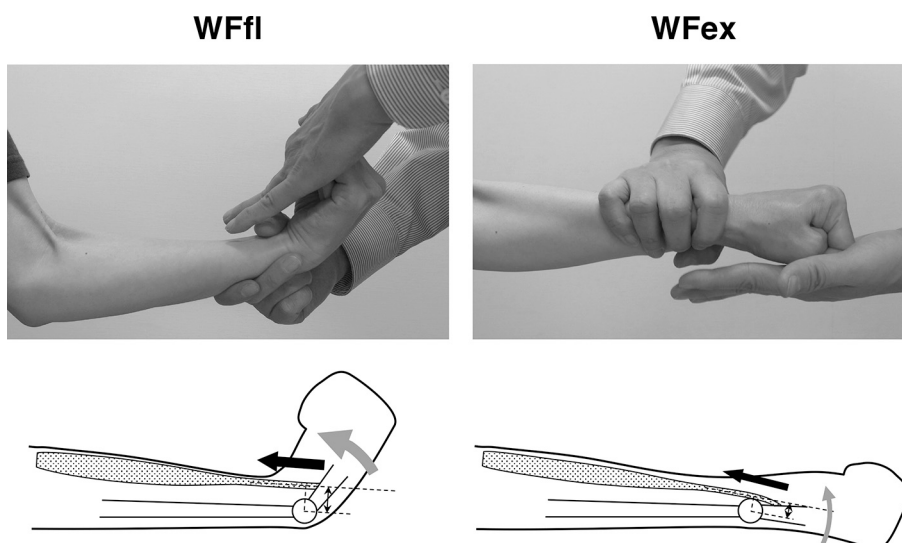


Fig. 1. The techniques of the MRC examinations and the underlying principle.

Upper: two postures of MRC examinations, WFfl (wrist flexion in the flexed position) and WFex, (wrist flexion in the extended position).

Lower: The underlying principle.

Black arrow: the maximal contraction force of the wrist flexion.

Double-headed arrow: the radius of rotation.

Gray arrow: the moment (torque) for the rotating movement at the wrist joint, i.e. force multiplied by radius.

The thickness of an arrow represents the magnitude of the force or moment.

For the FW group, the following were considered to be positive signs to support the diagnosis of FND, a) normal and symmetrical deep reflexes in asymmetrically weak limbs; b) negative Babinski’s sign in weak lower limbs; c) findings suggesting functional paresis in Hoover tests [8] or the Sonoo abductor test [9]; d) give-way weakness [10]; e) other neurological signs known to be functional such as cylindrical visual field. Another key finding supporting the diagnosis of FW was adopted from needle EMG; f) normal recruitment with poor activation and no denervation potentials in a weak muscle. Based on these, another inclusion criterion for the FW group was set as follows; 6) At least two of the above 6 items (5 clinical positive signs and an EMG finding) should be present. In this way, the new sign, paradoxical wrist flexion, was not included in the inclusion criteria. When functional symptoms overlapped an “organic” disorder (functional overlay), the patient was included only when the “organic” disease did not affect the power of the upper limb.

The retrospective study design was approved by the ethics committee of Teikyo University (approval number: 18–072 and 18–072-2).

2.3. Evaluated parameters and statistical analyses

Scores on the MRC scales for WFfl and WFex were primarily evaluated. For the FW group, the MRC score for WE was also evaluated. The comparison of two proportions in different groups was performed by chi-square test or Fisher’s exact probability test using Microsoft Excel for Macintosh.

3. Results

Twenty-four patients with FW (7 men and 17 women, age 37.9 ± 16.3 years, range 16–78) and 40 patients with OW (29 men and 11 women, age 60.3 ± 14.9 years, range 19–82) were enrolled. The distribution of weakness in the FW group and the disorders of the OW group are summarized in Table 1. In the FW group, the dominant side for the upper-limb paresis was right in 6, left in 15, and completely symmetrical in 3. In four of the 24 patients with FW, the weakness was not recognized by the patient before the neurological examinations, their chief complaints being just sensory symptoms in the upper limbs in 2 patients, and ocular symptoms in 2 patients suspected of myasthenia gravis.

The main results are summarized in Table 2. The “paradoxical wrist flexion” sign was positive in 16 patients with FW and in no patients with OW, i.e. 67% sensitivity and 100% specificity. The “organic sign” was positive in no patients with FW and in 35 patients with OW, i.e. 88% sensitivity and 100% specificity. The paradoxical wrist flexion sign was

Table 1
Characteristics of enrolled patients.

FND (n = 24)	
monoparesis	7
hemiparesis	7
tetraparesis	6
upper-limb paraparesis	2
hemiparesis + upper-limb paraparesis (3 limbs)	2
OND (n = 40)	
amyotrophic lateral sclerosis	10
spinal and bulbar muscular atrophy	1
Hirayama disease	1
cervical spondylotic amyotrophy	17
cervical spondylotic myelopathy	3
plexopathy	1
multifocal motor neuropathy	1
limb-girdle muscular dystrophy	1
polymyositis	1
inclusion body myositis	1
unknown myopathy	1
adult Alexander disease	1
intracranial lesion	1

Table 2
Main results regarding wrist flexion.

MRC scales of WFfl / WFex	FW group (n = 24)	WE = 5 (n = 17)	WE = 4 (n = 7)	OW group (n = 40)
4 / 5 (paradoxical wrist flexion)	15	14	1	0
3 / 4 (paradoxical wrist flexion)	1	0	1	0
paradoxical wrist flexion (total)	16 (67%)	14 (82%)*	2 (29%)*	0
4 / 4	8	3	5	5
5 / 4 (organic sign)	0	0	0	35 (88%)

* $p < 0.01$ using Fisher's exact probability test in comparison between patients having FW with WE = 5 and those with WE = 4.

positive even in 3 of the 4 patients with FW who were unaware of the weakness before the neurological examinations.

The relationship between paradoxical wrist flexion in the FW group and the MRC score for WE was also investigated (Table 2). Paradoxical wrist flexion was significantly more frequently observed when the MRC score for WE was 5 than when it was 4 ($p < 0.01$ using Fisher's exact probability test).

4. Discussion

The underlying principle of the paradoxical wrist flexion sign is that the WFfl should always be stronger than WFex in OW as well as in control subjects. The reason is explained in Fig. 1 (lower part). The length-tension relationship may not be simple in a specific muscle group, but the contraction force of the wrist flexor muscles is thought to become maximal when they are maximally shortened since wrist flexors are considered to act as functionally one-joint muscles [11]. Then, the contraction force of the wrist flexion would be stronger in the flexed position than in the extended (actually neutral) position. Furthermore, the radius of rotation would become obviously shorter in the extended position. Consequently, the moment (torque), which is the product of the force and the radius of rotation, will become much smaller in the extended position than in the flexed position. In OW, this principle is never violated and WFfl should always be stronger than WFex, although the two may be classified into the same grade.

In FW however, paradoxical wrist flexion, i.e. weaker WFfl than WFex, is frequently observed, which cannot be explained physiologically and therefore immediately suggests FND. The author has

speculated on the reason for this phenomenon as follows. In FW, an "active" movement, in which the patient feels that they are exerting a specific action with effort, is preferentially affected. Maximal wrist flexion, the test position for WFfl, is such an action. In contrast, a passive movement where a position is merely maintained is less affected. The test position for WFex belongs to the latter category.

The reason why paradoxical wrist flexion in the FW group was more frequently observed when WE was strong is explained as follows. When the MRC score for WE is 4, the patient recognizes that the whole wrist movement is weak. In this situation, it is unlikely that only WFex would be considered to be normal.

The sensitivity of the "organic sign" is an overestimate. When WFfl (always evaluated before WFex) was weak with an MRC score of 4 in a patient suspected of having OW, the separate evaluation of WFex was sometimes omitted. Furthermore, when the MRC score for WF is less than 4 for both WFfl and WFex, this method is not applicable. Here, the 100% specificity is more important. The presence of the "organic sign" excludes FW.

This study has several limitations. First, the examiner was not blinded to the diagnosis of the patient or any other neurological findings of the patient. This new sign itself was excluded from the inclusion criteria and the diagnosis of FND was retrospectively confirmed by the presence of other evidence. However, there remains the possibility that the diagnosis of FND was influenced by the observed paradoxical wrist flexion or that the supposed diagnosis of FND from other positive signs might have influenced the evaluation of the MRC scores. Although the author is an expert in the MRC scale evaluation [12] and tried to be as unbiased as possible, the unblinded design is a definite limitation of this study, as well as for other studies that have described new positive signs for FND [9,13,14]. Second, interrater difference was not tested in this study. The MRC scale is a subjective measure and considerable interrater variation is inevitable. Third, the diagnosis of FND has not been confirmed by sufficient follow-up in most cases. The possibility that misdiagnosis might have contaminated the results cannot be discounted. Fourth, the OW group included only two patients with central lesions (adult Alexander and intracranial lesion, actually a metastasis at the precentral lesion). Although the "organic sign" was positive for both patients, it has not yet been ascertained whether this sign is valid for patients showing central weakness who have spasticity, rigidity or altered motor programming.

The true diagnostic yield might be lower due to these limitations. Nonetheless, the results of this study are sufficiently clear-cut, strongly suggesting that the paradoxical wrist flexion test would be a useful tool in the daily practice of neurologists.

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Declaration of interest

None.

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Author Statement.

The sole author, Masahiro Sonoo, made all the planning of this study,

data collection and analyses, interpretations, and manuscript writing.

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