

# Spaghetti Wrist Trauma: Functional Recovery, Return to Work, and Psychological Effects

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**Background:** Few studies on spaghetti wrist trauma have been published. The study populations have all consisted of small numbers of patients, and most studies have focused on functional recovery. In addition, different definitions of this injury have been used. The objective of this study was to assess outcome for a larger group of patients in terms of functional recovery, return to work potential, and psychological distress, and to compare outcomes between the two most commonly used definitions for spaghetti wrist injury.

**Methods:** The initial study-population consisted of 67 patients. Fifty patients completed a questionnaire package consisting of the Disabilities of Arm, Shoulder, and Hand questionnaire, including the Functional Symptom Score (range, 0 to 100), a questionnaire to evaluate return to work and time off work (range, 0 to 52), and the Impact of Event Scale (range, 0 to 75). Motor recovery and sensory recovery were assessed in an outpatient setting, on average, 10 years (range, 2 to 18) after the operation ( $n = 43$ ).

**Results:** The mean Functional Symptom Score was 15.1 (SD, 16.1; range, 0 to 74) after a mean follow-up of 10.0 years (SD, 4.4; range, 2 to 18). Mean time off work was 34.7 weeks (SD, 17.9; range, 4 to

52), and 45.2 percent of the patients could not return to work within 1 year after the injury. Mean score on the Impact of Event Scale was 26.2 (SD, 19.7; range, 2 to 69). Compared with the unaffected hand, grip and tip pinch strength were decreased with means of 23.5 percent (SD, 22.4; range, 0 to 93) and 33.9 percent (SD, 23.7; range 0 to 83), respectively. Regarding sensory recovery, 12 patients (27.9 percent) had no protective sensation. No statistical differences were found between the two different definitions.

**Conclusions:** This study demonstrated that spaghetti wrist injury can be placed among the severe disabling injuries. Comparison of the two definitions did not reveal any differences in outcome. To complete the evaluation of long-term outcome, a patient-derived assessment of function can be added to the clinical examination, and attention should be paid to psychological distress following the injury. (*Plast. Reconstr. Surg.* 115: 1609, 2005.)

At the volar side of the wrist, 16 structures including 12 tendons, two nerves, and two arteries are located just beneath the skin, and are therefore vulnerable to injury. The “spaghetti wrist” or “full house” injury describes an exten-

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Presented at the Leiden International Medical Student Congress, in Leiden, The Netherlands, November 26 to 27, 1999; the Scandinavian-Hungarian Hand Society meeting, in Kuopio, Finland, August 16 to 19, 2000; and the Annual Meeting of the Netherlands Society for Surgery of the Hand, in Eindhoven, The Netherlands, November of 2001.

DOI: 10.1097/01.PRS.0000160697.41738.EA

sive volar wrist laceration in which several of these structures are injured.

Besides amputation, combined injury of nerves, flexor tendons, and arteries at wrist level may be the most traumatizing injury to the forearm. Nerve injury causes loss of motor and sensory functions of the hand. Diminished grip strength, imbalance of hand movements due to loss of intrinsic muscle functions, and loss of sensation in some or all fingers leave the hand as a nonfunctional tool. Laceration of several flexor tendons can lead to extensive scar tissue formation, resulting in elimination of differential gliding of the tendons.<sup>1</sup>

Despite the devastating nature of spaghetti wrist injury, little attention has been paid to this extensive wrist trauma.<sup>2-6</sup> Various definitions have been used, ranging from a relatively minor injury of three lacerated structures, including injuries without nerve-laceration, to a major trauma with laceration of at least 10 structures including the median and/or ulnar nerve. Therefore, comparison of these studies is difficult. In addition, numbers of patients reported are small and all studies focused on functional outcome (e.g., motor and sensory recovery). Little attention was paid to the impact of a spaghetti wrist trauma on employment and to posttraumatic psychological stress.

The main objective of this study was to assess long-term outcome following spaghetti wrist injury for a large group of patients. Apart from evaluation of motor and sensory recovery, attention was paid to performance of activities of daily living, ability to return to work, and the psychological impact of a spaghetti wrist trauma. Furthermore, this study aimed to compare the two most commonly used definitions for spaghetti wrist injury by means of statistical analysis of long-term outcome applying these two different definitions.

## PATIENTS AND METHODS

### Study Population

Records of patients with peripheral nerve injury of the upper extremity operated on between January of 1980 and December of 1998 at the Erasmus Medical Center, University Medical Center Rotterdam, were reviewed ( $n = 313$ ). The inclusion criterion for spaghetti wrist injury was defined as an injury at wrist level located between the distal wrist crease and the flexor musculotendinous junctions (zone 5) that met one or both of the following definitions: (1) simultaneous laceration of both the median and ulnar nerves with flexor tendons at the wrist<sup>3,4</sup> and/or (2) at least 10 divided structures including the median and/or ulnar nerve.<sup>5,7</sup>

Patients with associated hand fractures or amputation of the hand or fingers were excluded. Finally, according to these criteria, 67 patients were included in the study (69 cases; two patients injured both arms). A summary of injuries is listed in Table I.

To trace these patients' hospital medical records, general practitioners and municipal archives were consulted. A questionnaire package was sent to patients whose addresses could be retrieved ( $n = 60$ ). Three follow-up mailings were sent to nonresponders in 2-month intervals. Fifty patients returned the questionnaires. Ten patients rejected participation. The remaining seven patients were untraceable (four had moved abroad, one had died without any relation to the operation, and two were not known by municipal records). All responders were invited to our hospital for a visit in an outpatient setting to assess motor and sensory recovery. Patients unable to come to our hospital were visited at home. Seven patients rejected this invitation.

TABLE I  
Summary of Injuries ( $n = 67$ )

	Median	Ulnar	Combined
Total of severed structures	11.7 ± 1.4	10.7 ± 0.8	10.6 ± 3.7
Total of severed tendons	9.9 ± 1.1	8.7 ± 0.8	8.3 ± 3.0
Artery			
Ulnar	3 (17.6%)	7 (100%)	31 (68.9%)
Radial	4 (23.5%)	0 (0%)	0 (0%)
Radial-ulnar	3 (17.6%)	0 (0%)	6 (13.3%)
Definition*			
1	0	0	16
2	17	7	0
1 and 2	0	0	29

\* Definition 1, combined median and ulnar nerve injury; definition 2, minimum of 10 lacerated structures including at least one major nerve.

The investigators had not been involved in the patients' operation or treatment following the injury. The protocol of the study was approved by the Medical Ethics Committee of the Erasmus Medical Center, University Medical Center Rotterdam, and informed consent was provided by all participants.

### Questionnaires

The questionnaire package consisted of three questionnaires. To assess functioning in daily living, the Disabilities of Arm, Shoulder, and Hand questionnaire, version 2.0 (May of 1997) was used.<sup>8,9</sup> It was translated according to the criteria of the Institute for Work & Health and the American Academy of Orthopedic Surgeons. Five translations and two "back translations" by two native speakers were compared, aiming for semantic, idiomatic, and conceptual equivalence. Using a self-report system, patients attribute scores of 1 to 5 (Likert scale) on 30 items related to functional activities (such as preparing a meal and writing) and symptoms (such as pain and weakness). The raw Functional Symptom Score is then transformed to a 0 to 100 scale, whereby 0 reflects minimum and 100 maximum disability.

A questionnaire concerning profession and return to work had been developed by the authors and was applied to examine return to work and time until resumption of work. No distinction was made between returning to the preinjury job and finding new employment.

The Impact of Event Scale<sup>10</sup> was selected to establish psychological impact and posttraumatic psychological stress. Since its introduction in 1979, by Horowitz and co-authors, it is widely used. It is a 15-item self-report questionnaire that assesses stress-related symptomatology and records patients' subjective responses to the traumatic event. Patients were asked to think of the period until a month following the accident and rate questions such as: "I had trouble falling asleep or staying asleep because of pictures or thoughts about it that came into my mind," "I tried not to think about it," and "Any reminder brought back feelings about it." Each item has a scoring range of 0 to 5 on a four-point scale (0 = not at all, 1 = rarely, 3 = sometimes, and 5 = often), with seven items covering intrusive symptoms and eight items avoidance symptoms. Total Impact of Event Scale scores range from 0 to 75 (worst score). After their visit at our outpatient clinic, pa-

tients were asked to complete the scale again for the current psychological status.

### Follow-Up Review

During a 1-hour session in an outpatient setting, motor and sensory recovery was examined. To assess motor recovery, grip and tip pinch strength were measured using a Jamar Hydraulic Hand Dynamometer and Hydraulic Pinch Gauge meter (kilograms force; DeRoyal Industries, Powell, Tenn.) as described by Mathiowetz.<sup>11,12</sup> Both the injured and uninjured hand were tested three times. In case the third measurement was the highest, a fourth measurement was performed. All results were noted, and the mean was calculated. Results were mapped as percentage loss compared with the unaffected hand with a scoring range from -100 percent to 100 percent. Corrections for hand dominance were made according to Petersen.<sup>13</sup>

Manual Muscle Strength Tests were performed, as described by Brandsma et al.,<sup>14</sup> to evaluate recovery of the intrinsic muscles of the hand. Scores were noted using the Modified Medical Research Council Scale (Table II).<sup>14</sup> Muscles tested with the Manual Muscle Strength Tests were the abductor digiti minimi, the first dorsal interosseous, the abductor pollicis brevis, the opponens pollicis, and the dorsal lumbricals/interossei II-IV. In one of the responders, nerves of both the left and right arm were injured. No valid reference for motor recovery could be obtained. Therefore, this patient was excluded from analysis concerning motor recovery.

Sensory recovery was tested with Semmes-Weinstein monofilaments (North Coast Medical, Morgan Hill, Calif.). The monofilaments (2.83, 3.61, 4.31, 4.56, and 6.10, ranked 1 to 5) were used according to the procedure described by Bell-Krotosky.<sup>15</sup> Ten zones in the

TABLE II  
Recovery of the Intrinsic Muscles Scored According to the Modified Medical Research Council Scale

Intrinsic Muscle Recovery	Grade	Range of Movement	Resistance
Excellent	5	Normal	Normal
Good	4	Normal	Reduced
Fair	3	Normal	None
Fair	2	Reduced	None
Poor	1	None	Palpable contraction only
Failure	0	None	No palpable contraction

hand were tested, six in the area of the median nerve and four in the area of the ulnar nerve. The scores were interpreted as suggested by Imai.<sup>16</sup> A score of 6.10 was interpreted as anesthetic.

### Statistical Analysis

Participants and nonparticipants were compared using chi-square analysis for categorical data and *t*-tests for continuous variables to detect if selection bias had occurred (Table III). In case the expected count of the cells was less than five, the Fisher's exact test was used. Subjects who attempted suicide ( $n = 6$ ; 12 percent) were excluded from analysis concerning the Impact of Event Scale, because they were more likely to have extensive psychological problems preexisting to injury. To investigate psychological stress following a spaghetti wrist trauma, a homogenous population was needed. Most nerve injuries have an accidental cause. Inclusion of the patients who attempted suicide might lead to misinterpretation of the results. To compare the two definitions, patients who matched both definitions ( $n = 29$ ) were randomly divided between the two definitions. To check if randomly dividing the pa-

tients who met both definitions did not change the results, we redid the analysis after exclusion of the patients who fulfilled both definitions. Differences in outcome between the two definitions were examined by the nonparametric Mann-Whitney *U* test for continuous data. Categorical data were analyzed using the chi-square test, and if the expected values in one of the cells were less than five, the Fisher's exact test was used. All tests were performed two-sided, and a *p* value of  $<0.05$  was considered statistically significant. Data analysis was performed using SPSS statistical software (version 9.0, Real Stats; SPSS, Chicago, Ill.).

## RESULTS

### Study Population

The study population consisted of 67 patients. A total of 50 patients returned the questionnaires. Table III lists patient characteristics for responders and nonresponders. No statistical difference was found between the responders and nonresponders for sex ( $p = 1.0$ ), age ( $p = 0.55$ ), type of injury ( $p = 0.36$ ), injury of the dominant hand ( $p = 1.0$ ), and time between injury and follow-up ( $p = 0.21$ ).

### Questionnaires

The mean Functional Symptom Score was 15.1 (SD, 16.1; range, 0 to 74) after a mean follow-up of 10 years (range, 2 to 18). Thirty-one patients were employed on the day of injury. Twenty-nine of the subjects (93.5 percent) took sick leave, with a mean of 34.7 weeks (SD, 17.9; range, 4 to 52), and 14 patients (45.2 percent) did not return to work within 1 year. One month postoperatively, mean score on the Impact of Event Scale was 26.2 (SD, 19.7; range, 2 to 69). The mean scale score during follow-up, on average 10 years after the trauma, was 7.3 (SD, 11.2;  $p < 0.001$ ).

### Follow-Up Review

Forty-three patients were available for follow-up review. One of these patients sustained spaghetti wrist injury to both his left and right arm; therefore, the number of injuries is 44. Regarding grip and tip pinch strength, mean losses of 23.5 percent (SD, 22.4; range, 15 to 93) and 33.9 percent (SD, 23.7; range, -25 to 83) were found, respectively. Results for Manual Muscle Strength Tests are listed in Table IV. For results of the Semmes Weinstein monofilament testing for sensory recovery, see Table V.

TABLE III

Patient Characteristics of Responders and Nonresponders  
( $n = 67$ )

Variable	Responders	Nonresponders
No. of patients	50	17
Sex		
Male	42 (84.0%)	15 (88.2%)
Female	8 (16.0%)	2 (11.8%)
Age, years		
Mean $\pm$ SD	29.1 $\pm$ 12.4	31.2 $\pm$ 13.5
Range	8-58	18-71
Type of injury		
Glass	32 (64.0%)	8 (47.1%)
Knife	7 (14.0%)	6 (35.3%)
Other	11 (22.0%)	3 (17.6%)
Environment		
Home	20 (40.0%)	4 (23.5%)
Work	12 (24.0%)	2 (11.8%)
Suicide attempt	6 (12.0%)	6 (35.3%)
Other	12 (24.0%)	5 (29.4%)
Dominant hand affected		
Yes	27 (54.0%)	4 (23.5%)
No	19 (38.0%)	2 (11.8%)
Unknown	4 (8.0%)	11 (64.7%)
Definition		
1	34	10
2	36	16
1 and 2	20	9
Time since injury, years		
Mean $\pm$ SD	11.0 $\pm$ 4.4	12.7 $\pm$ 5.4
Range	3-19	3-20

TABLE IV  
Results for Manual Muscle Strength Testing (*n* = 43)

Muscle	Mean ± SD	No. of Patients Recovering Grade 4 or 5
Abductor digiti minimi	2.8 ± 1.4	11
First dorsal interosseous	2.7 ± 1.5	12
Lumbricals/interossei	3.6 ± 1.2	24
Abductor pollicis brevis	3.5 ± 1.6	25
Opponens pollicis	3.8 ± 1.3	28

Comparing Two Definitions

In Tables VI through VIII, the two definitions are compared for Functional Symptom Score (Table VI), return to work (Table VI), psychological distress (Table VI), motor recovery (Table VII), and sensory recovery (Table VIII). Statistical analysis on these results showed no significant differences in outcome between the two definitions. Difference for sensory recovery was shown to be borderline statistically significant. Mean grade of sensory recovery for definition 1 and 2 was, respectively, 3.8 (SD, 1.0) and 3.2 (SD, 0.9) (*p* = 0.07). After exclusion of the patients who fulfilled both definitions, patients who met definition 2 (median, 3.5) had a statistically better outcome for sensory recovery compared with the patients who met definition 1 (median, 3.9) (*p* = 0.03). No statistical difference was found between both definitions for the Functional Symptom Score, weeks of sick leave, return to work within 1 year, Impact of Event Scale score, grip strength, tip pinch strength, and Manual Muscle Strength Test result after exclusion of the patients who fulfilled both definitions.

DISCUSSION

This study demonstrated that despite a mean follow-up of 10 years, spaghetti wrist patients were still functionally impaired in performing certain tasks of daily living. The impact of spaghetti wrist injury on employment is not to be underestimated. Almost half of the study pop-

TABLE V  
Results of Semmes Weinstein Testing (*n* = 43)

Quality of Sensation	Filament	No. of Patients
Normal	2.83	0
Diminished light touch	3.61	5
Diminished protective sensation	4.31	17
Loss of protective sensation	4.56	15
Anesthetic	6.10	7

TABLE VI  
Comparing Two Definitions: Questionnaires (*n* = 50)\*

Variable	Definition 1	Definition 2	<i>p</i>
No. of questionnaires returned	24	26	
FSS			
Mean ± SD	16.9 ± 17.7	13.5 ± 14.5	0.39
Range	1-74	0-53	
Employment			
No. of workers	17 (70.8%)	14 (53.8%)	
Weeks of sick leave			
Mean ± SD	36.4 ± 18.8	32.8 ± 17.5	0.54
Range (min. 0; max. 52)	4-52	10-52	
RTW within 1 year	8 (47.1%)	9 (64.3%)	
No RTW within 1 year	9 (52.9%)	5 (35.7%)	0.34
IES score			
Mean ± SD†	26.5 ± 20.7	28.9 ± 21.6	0.69
Range†	4-71	2-75	

FSS, Functional Symptom Score; RTW, return to work; IES, Impact of Event Scale.

\* Definition 1, combined median and ulnar nerve injury; definition 2, minimum of 10 lacerated structures including at least one major nerve.

† Intrusion and avoidance subscales.

ulation employed on the day of injury could not return to work within 1 year following the accident. Moderate to severe psychological symptoms (Impact of Event Scale score > 17) during the first month following the injury were present in 28 patients (64 percent).

Previous studies on spaghetti wrist injury mainly assessed sensory recovery, motor recovery, and range of motion to evaluate long-term functional outcome.<sup>2-6</sup> Although these three factors can all limit a patient in the performance of certain activities of daily living, none of these studies collected data about the patient's daily functioning. The Disabilities of Arm, Shoulder, and Hand questionnaire provides an easy and valid method to evaluate

TABLE VII  
Comparing Two Definitions: Motor Recovery (*n* = 43)

Variable	Definition 1	Definition 2	<i>p</i>
No. of patients seen in follow-up session	22	21	
Grip strength*			
Mean ± SD	26.0 ± 26.1	20.7 ± 17.5	0.56
Range	-15 to 93	-2 to 59	
Tip pinch strength*			
Mean ± SD	36.9 ± 27.2	30.5 ± 19.0	0.23
Range	-25 to 83	0 to 75	
MMST (mean ± SD)			
Abductor digiti minimi	3.0 ± 1.5	2.6 ± 1.3	0.22
First dorsal interosseous	2.9 ± 1.6	2.5 ± 1.3	0.46
Lumbricals/interossei	3.5 ± 1.3	3.9 ± 1.0	0.92
Abductor pollicis brevis	3.3 ± 1.8	3.8 ± 1.3	0.41
Opponens pollicis	3.5 ± 1.5	4.1 ± 1.0	0.21

MMST, Manual Muscle Strength Tests.

\* Percentage loss compared with the nonaffected hand.

TABLE VIII  
Comparing Two Definitions: Sensory Recovery ( $n = 43$ )

Semmes Weinstein	Grade	Definition 1	Definition 2
Normal (2.83)	1	0 (0.0%)	0 (0.0%)
Diminished light touch (3.61)	2	2 (9.1%)	3 (13.6%)
Diminished protective sensation (4.31)	3	8 (36.4%)	9 (40.9%)
Loss of protective sensation (4.56)	4	8 (36.4%)	7 (31.8%)
Anesthetic (6.10)	5	4 (18.2%)	3 (13.6%)

$p = 0.07$ .

functional impairment in daily living.<sup>17</sup> It can detect and differentiate small and large changes of disability over time after the operation.<sup>18</sup> Recently, population-based norms for the questionnaire have been collected, and a significant association between the severity of the injury and the Functional Symptom Score was described.<sup>19,20</sup> Quality of motor and sensory recovery following upper extremity nerve injuries is related to the Functional Symptom Score.<sup>21</sup> Findings in this study indicated that spaghetti wrist injury has a long-lasting high impact on performance of daily living activities. Only two patients (4.0 percent) were not disabled in daily living functioning (Functional Symptom Score = 0) after a mean follow-up of 10 years. For example, one of our patients with an Functional Symptom Score of 15 complained of moderate difficulties with writing, mild difficulties preparing a meal, severe problems with recreational activities in which the arm is moved freely, and having moderate stiffness, tingling, and/or weakness in arm, shoulder, or hand. Since the introduction of the Disabilities of Arm, Shoulder, and Hand questionnaire in 1996, an increasing amount of studies used the Functional Symptom Score to evaluate functional disability. Functional symptom scores varied between 2 for proximal phalanx fractures and 52 for distal biceps rupture.<sup>22,23</sup> Variation of the Functional Symptom Score is caused by difference in the severity of injury and length of follow-up. On average, 5.5 years following the operation combined median-ulnar nerve injuries reported a mean score of 24.<sup>21</sup> Comparative scores for other hand injuries are 29 for a ray amputation (follow-up, 32 months)<sup>24</sup> and 13 for a scaphoid fracture (follow-up, 66 months)<sup>25</sup> Besides evaluation of motor and sensory recovery by a physician, the inclusion of a patient-completed questionnaire concerning daily living functioning can be an easy method to optimize the evaluation of short- and long-term functional recovery following nerve injury. In addition, this could

facilitate comparison of results between studies.<sup>26</sup>

Return to productivity is becoming an issue of growing national concern for economic reasons.<sup>27</sup> Many studies reported on return to work following trauma or illness.<sup>4,27-31</sup> Despite the suggestion that extremity injuries disproportionately contribute to long-term disability,<sup>27-31</sup> return to productivity has been underexposed in the previous studies on spaghetti wrist injuries. Rogers et al.<sup>4</sup> reported an 87.5 percent return-to-work ratio among patients with combined median and ulnar nerve injuries. Taha and Taha<sup>29</sup> reported a 0 percent return-to-work ratio among patients with combined median and ulnar nerve injury following missile injuries. Both studies reported small numbers of patients (eight and seven patients, respectively). The present study showed that 45.2 percent of the employed patients did not return to work within 1 year following the injury. Furthermore, spaghetti wrist patients took sick leave with a mean of 35 weeks.

Throughout history, the hand has been identified as an important component of human anatomy, unique in structure and function.<sup>32</sup> Because the hand is frequently used as a non-verbal medium of communication, a disfigured hand results in negative changes in self-image.<sup>33</sup> Earlier studies reported on psychological problems following severe hand trauma.<sup>32,33</sup> Grunert et al.<sup>33</sup> found that 94 percent of patients with severe hand injury experienced psychological symptoms at some point early in rehabilitation. Richmond et al.<sup>34</sup> reported a mean Impact of Event Scale score of 30.6 among patients 3 months after a noncentral nervous system trauma. To our knowledge, no reports have been published on psychological distress following spaghetti wrist injury. In our study population, psychological impact was considerable; 64 percent of the patients experienced a moderate (score, 18 to 39) to severe (score > 40) psychological response within the first month following the injury. This study

reported an average Impact of Event Scale score of 26 one month postoperatively, which is comparable to the amount of psychological stress found among the survivors of the cruise ship Estonia.<sup>35</sup> Patients with scores greater than 30 have sufficient symptoms to be in the need for psychological treatment, and patients whose initial scores are over 19 have a 12.4 times higher risk of developing a posttraumatic stress disorder than patients whose scores were 19 or less.<sup>36</sup> Predictors for the amount of posttraumatic psychological stress following median and ulnar nerve injuries are number of severed structures, combined versus single nerve injuries, and sex. Education was found to be a protecting variable.<sup>37</sup> There were limitations to this part of the study. Retrospective data collection will tend to underestimate the amount of psychological stress. Patients may have failed to recall their reaction to their traumatic nerve injury. On the other hand, patients with worse functional outcome and reduced capacity for work may tend to exaggerate the amount of psychological stress. Despite these limitations, it can be concluded that the early psychological consequences of spaghetti wrist injury are not to be underestimated. During follow-up, on average 10 years postoperatively, spaghetti wrist patients reported a statistical decrease of the Impact of Event Scale score. Early recognition and treatment of patients who are at great risk to develop a posttraumatic stress disorder may influence the functional outcome. Results on the clinical utility of the scale showed that it has sufficient reliability and validity to warrant its use as a clinical screening method for traumatic stress.<sup>38,39</sup>

Nerve injury causes motor and sensory loss of the hand. Several previous studies reported on motor recovery following nerve injury.<sup>2-6,40-43</sup> Our results are comparable with findings in these studies, although reports on grip and tip pinch strength recovery vary. We found overall recovery of intrinsic muscles to be better than reported by others.<sup>2-6,40-43</sup>

Reports on sensory recovery vary but are overall dissatisfying, with most patients recovering only gross protective sensation.<sup>2-6</sup> Our findings on sensible recovery were disappointing, with 12 patients losing protective sensation and seven patients recovering no sensation.

Three different definitions are used to define spaghetti wrist injury. In this study, we tried to reach consensus on which definition

can be used best by means of statistical analysis of differences between two definitions (combined median and ulnar nerve injury and laceration of 10 or more structures including at least the median and/or ulnar nerve). The third definition used in literature, a laceration of at least three structures,<sup>2,6</sup> can be applied to most minor injuries to the wrist, including injuries without nerve laceration. In our opinion, this describes an injury with less severe functional consequences compared with injuries described by the other two definitions. Therefore, we did not use this third definition in our study. Statistical analysis showed no significant differences in outcome between the two definitions (Tables VI through VIII). A statistical difference was found for sensory recovery only after excluding the patients who met both definitions. So it seemed that the combined median and ulnar nerve injuries have worse prospects concerning sensory recovery compared with the single nerve injuries. Perhaps the larger area in the somatosensory cortex, which needs to be reorganized, can explain this finding. Focusing on the descriptive character of the name spaghetti wrist, we agreed with Katz<sup>7</sup> and considered the second definition, "a minimum of 10 completely injured structures, including at least one major nerve," the most appropriate to describe spaghetti wrist trauma.

Spaghetti wrist injuries can be placed among the severe disabling injuries. Assessment of functional recovery involves more than the evaluation of motor and sensory recovery by a physician. Besides a clinical examination, assessment of long-term outcome following nerve injury should include a patient-derived assessment of function, evaluation of the return-to-work ratio, and assessment of psychological distress. Furthermore, we recommend that in future studies spaghetti wrist injury be defined as a laceration of the volar wrist with a minimum of 10 structures involved including at least the median and/or ulnar nerve.

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#### ACKNOWLEDGMENTS

This research was financially supported by the Esser Foundation Rotterdam and the Foundation Vereniging Trustfonds Erasmus Universiteit Rotterdam, The Netherlands.

The authors acknowledge Coen N. P. Bruyns for his tireless support in patient recruitment. Furthermore, grateful thanks are expressed to Teun Luystenburg, who supported the development of the database and the nerve injury chart.

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