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Original article

Construct validity of the Patient-Rated Wrist and Hand Evaluation questionnaire (PRWHE) for nerve repair in the hand

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ABSTRACT

Background: Many tools have been described for outcome assessment after nerve repair. The Patient-Rated Wrist and Hand Evaluation (PRWHE) have been shown to be valid for several hand conditions.
Objectives: To explore the construct validity of the PRWHE in comparison to cold intolerance, pain and dysfunction questionnaires; the Rosén score and its subcomponents; and threshold sensibility, dynamometry and dexterity tests for nerve repair of the hand.
Study design: Clinical measurement.
Methods: Construct validity was analysed through Pearson's correlation coefficient in a convenience sample of 32 adult patients after long-term median and ulnar nerve repair.
Results: The PRWHE total score was highly to moderately associated with the Disability of Arm, Shoulder and Hand ($r = 0.83$), Cold Intolerance Symptom Severity ($r = -0.60$) and McGill's Pain ($r = 0.58$) questionnaires. In addition, it was correlated to motor ($r = -0.55$) and sensor subdomains ($r = -0.56$) of the Rosén score. Substantial to high associations were found for the motor, sensory impairment and dexterity test.
Conclusions: The PRWHE was shown to be valid, based on construct validity, for patients with nerve repair of the hand.

1. Introduction

Traumatic nerve injuries of the wrist and hand are common, with a higher incidence in young males (Fonseca et al., 2006; Trybus et al., 2006; Saadat et al., 2011; Gupta et al., 2012). These lesions often have lifelong negative consequences on hand function, economic productivity and quality of life (Jaquet et al., 2001; Rosberg et al., 2005).

A wide variety of outcome measures have been proposed for upper limb disorders, including nerve repair (Novak, 2001; Bucher and Hume, 2002; Rosén and Lundborg, 2003; Jerosch-Herold, 2005; Seftchick et al., 2011). Some are patient-report outcome measures (PROs), whereas others are performance-based (Bergner and Rothman, 1987; MacDermid, 2011; Badalamente et al., 2013a). PROs can target a specific anatomic region or health condition or be generic, such that they can be used with all health conditions (Hudak et al., 1996; Chung et al., 1998; Amadio, 2001; Changulani et al., 2008; De Smet, 2008; Naidu et al., 2009; Van de Ven-Stevens et al., 2009; Badalamente et al., 2013b). The Patient-Rated Wrist and Hand Evaluation (PRWHE) (MacDermid, 1996) is a 15-item, region-specific PRO designed with two subscales (5 items for pain and 10 items for function) and a complementary aesthetics sub-item, scored separately. The psychometric properties of the PRWHE questionnaire have been evaluated and have been found to have high reliability and good construct validity (MacDermid et al., 1998). The PRWHE has been validated for distal

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radial fractures (MacDermid et al., 2000, 2001, 2003) and several other hand conditions, such as carpometacarpal joint osteoarthritis (Angst et al., 2005; MacDermid et al., 2007), scaphoid malunion (Kołodziej et al., 2006) and radial ulnar joint instability (Johnston et al., 2009). It may be slightly more responsive than the Disability of the Arm, Shoulder and Hand (DASH) questionnaire (MacDermid and Tottenham, 2004). It has been translated into several languages and validated in various countries (Voche et al., 2003; Xu and Seow, 2003; Wah et al., 2006; Hemelaers et al., 2008; John et al., 2008; Brink et al., 2009; Wilcke et al., 2009; Imaeda et al., 2010; Mellstrand Navarro et al., 2011; Mehta et al., 2012; Rodrigues et al., 2015).

For nerve injuries of the hand, a battery of performance-based tests can be used to assess sensory and motor domains (Novak, 2001; Jerosch-Herold, 2005; Vordemvenne et al., 2007; Kim et al., 2011). However, a few PROs have been validated for use in nerve repair populations (Kim et al., 2011). PROs can augment the clinical information derived from performance-based outcome measures (MacDermid, 2005). Therefore, the purpose of this study was to analyse the construct and discriminative validity of the PRWHE questionnaire in a sample of patients a year or more following nerve injury and subsequent repair of the wrist and/or hand. Thus, we analysed the correlation between the PRWHE questionnaire for wrist and hand with:

a) Functional domain: the DASH disability questionnaire, Cold Intolerance Symptom Severity questionnaire (CISS), McGill Pain Questionnaire (MPQ) and Rosén score,
b) Sensory domain: threshold sensibility assessed using Semmes Weinstein Monofilaments test (SWM™) and the Pressure-Specified Sensory Device (PSSD™),
c) Motor domain: grip and pinch strength measured with dynamometry and hand dexterity using the NK hand dexterity test (NKHDT)™,

Discriminative validity was measured by testing differences in known groups expected to have different outcomes (partial and full laceration).

2. Methods

2.1. Patients

This study used a cross-sectional design. Participants were recruited from a Hand Therapy Unit.

The sample consisted of 32 consecutive patients who underwent nerve repair between 2001 and 2008. Volunteers were eligible for the study if they had previous hand trauma with nerve injury followed by repair of the forearm, wrist or hand at least one year after repair. They were invited by letter to attend an assessment battery day. Inclusion criteria were: able to read English and at least 18 years old. Exclusion criteria were: (a) the presence of a rheumatologic or neurological background such as stroke or neuropathy and (b) concomitant injuries of other upper extremity joints.

The local ethics committee approved this study and all participants gave informed consent prior to their participation.

2.2. Outcomes

The patients who agreed to participate in this study completed all the questionnaires. Data were collected by the same physiotherapist (MCRF) with experience in hand therapy in a standard clinical protocol for motor and sensory outcomes (Seftchick et al., 2011). MCRF conducted data collection, analysis and interpretation of data and preparation of the manuscript. EL collaborated in data collection and checking, as well, drafted the manuscript. AMN and RIB participated in the statistical analysis and preparation of the manuscript. NCS and RMMS participated in the analysis and interpretation of data and preparation of the manuscript. JCM participated in the design and coordination of the study, analysis and interpretation of data and preparation of the manuscript. All authors read and approved the final manuscript.

2.3. Functional domain

The volunteers completed four PRO questionnaires related to disability and pain, as described below. The PRWHE questionnaire for wrist and hand has 15 items related to pain, specific function tasks and usual ability in personal care, work, household, and recreation (MacDermid, 1996; MacDermid et al., 1998; MacDermid et al., 2007). The DASH questionnaire has 30 items that evaluate symptoms and physical function using a Likert scale with a five-response option for each item. Both the PRWHE and the DASH are scored from 0 to 100, with higher scores indicating greater disability (Hudak et al., 1996; Beaton et al., 2001). The CISS questionnaire for cold sensitivity consists of six questions involving the occurrence of pain, numbness, stiffness, weakness, aching, swelling and skin color change to white or blue, with a focus on the impact of cold intolerance in daily life activities; lower scores reflect the best tolerance (Ruijs et al., 2006; Carlsson et al., 2008). The MPQ consists of three major classes of word descriptors that quantify the sensory, affective and evaluative components of pain (Melzack, 1975; Pearce and Morley, 1989).

The Rosén score, ranging from 0 to 3, was also collected. It is a valid outcome tool that represents a combination of selected instruments clustered in partial subdomains: motor domain (motor innervation and grip strength), sensory domain (sensory innervation, tactile gnosis, and finger dexterity), and pain/discomfort domain (hyperesthesia and cold intolerance) (Rosén and Lundborg, 2003).

2.4. Sensory domain

The sensory domain was evaluated using the Semmes-Weinstein monofilaments (SWM™) test (Bell-Krotoski, 2011) and the Pressure Specified Sensory Device (PSSD™) (Tassler and Dellon, 1995). Both were performed by an independently-trained evaluator (EL). SWMF five-piece kits were used and applied sequentially from the 2.83 filament to detection using five repeat applications. The PSSD™ was applied slowly; patients indicated detection by firing a trigger held in their unaffected hand.

2.5. Motor domain

The motor domain was assessed using the NKHDT™ computerised hand evaluation system. The measurements performed included grip and pinch strength dynamometry performed with the elbow flexed and the forearm/wrist in neutral position. The NKHDT™ dexterity board was used to measure the patient's ability to manipulate small, medium and large objects in a standardised timed test (Turgeon et al., 1999).

All evaluative tools and tests chosen in this study were selected to represent impairments commonly tested in clinical practice; all were particularly related to nerve repair (Callahan, 2011). All procedures were performed on the affected hand in a standardised protocol, following the recommendations of the American Society of Hand Therapists (ASHT, 1992).

2.6. Statistical analysis

We analysed the instrument's construct validity by examining the extent of association between the PRWHE and comparable assessments using Pearson's correlation coefficient (r). We categorised correlation coefficients as follows: $r < 0.32$ as low; $0.32 \leq r < 0.45$ as moderate; $0.45 \leq r < 0.60$ as substantial; and $r > 0.60$ as high (Burnand et al., 1990; Staples et al., 2010).

To evaluate known groups' discriminative validity, we compared the

outcomes of partial (n = 11) and full (n = 11) traumatic lesions, excluding the combined cases of neuroma (n = 2) or full laceration associated with compression (n = 1). There were seven participants for whom we could not find the type of nerve injury in the records. The nonparametric Wilcoxon test was used to determine discriminative validity for the variable total score of PRWHE ($p < 0.05$). All data were analysed using SPSS 19™ (SPSS Inc.; Chicago, IL).

3. Results

The majority of patients included in our study were males (78.1%); mean age 42.28 ± 15.51 years; right-handed (90.6%); with median and ulnar nerve injury as a result of a cut by glass, knife or tool (84.4%); on the volar aspect of the wrist (43.8%); with the right side affected in 53.1% of the sample. Most of them had primary nerve repair (68.8%); with the use of a microscope (78.1%); with 9-0 nylon suture to nerve reconstruction (50%), most surgeries took place on the same day or within the first two weeks after trauma. The mean time between surgery and the study was 4.7 ± 2.2 years (range 1–8 years). Most patients participated in hand therapy (81.3%) and reported using an orthoses (62.5%). At the time of the evaluation, most patients reported no other disease or the use of pain medication, cigarettes or alcohol, and had not changed jobs due to the hand trauma. A minority of the injuries were Workers Compensation Board cases (28.1%); 65.6% were employed in full-time regular duties and 84.4% had completed technical or high school.

Mean score values of evaluations suggested that the sample has low residual impairment and disability, although there was substantial variation in outcomes; the total Rosén score had intermediate values (Table 1).

3.1. Construct validity

Moderate to high correlations were found between the subcomponents pain and function of the PRWHE and the motor ($r = -0.66$, $r = -0.55$), sensory ($r = -0.44$, $r = -0.56$) and discomfort/pain ($r = 0.58$) domains on the Rosén score, but not, however, between the total Rosén score and the total PRWHE, which was low ($r = -0.25$). The PRWHE had a high association with the DASH ($r = 0.83$) and a substantial association with the CISS ($r = 0.60$). There was a substantial to high association of the subcomponents of the MPQ (Motivational affective, Cognitive evaluative, Miscellaneous) and the total MPQ with the total PRWHE ($r = 0.50$, $r = 0.61$, $r = 0.66$, $r = 0.58$), except in terms of PRWHE appearance and sensory discrimination. Moderate to high associations were found between the total PRWHE and the measures of motor, sensory impairment and dexterity (Table 2).

No statistically significant difference was found in a comparison between known subgroups of nerve injury (partial x full laceration); this therefore offers no discriminative validity.

Table 1
Patient-report outcome measures (PROs) and Rosén score in the sample (32) of nerve repair.

Scores	Mean	SD	Range	Median
PRWHE	27.10	24.71	0–81.5	23
DASH	18.04	21.70	0–78.33	6.66
MPQ	16.72	12.55	0–50	15
CISS	34.48	23.80	0–91	29
Rosén score	1.65	0.26	1.34–2.31	1.59

PRWHE = Patient-Rated Wrist and Hand Evaluation; DASH = Disability of Arm, Shoulder and Hand; MPQ = McGill Pain Questionnaire; CISS = Cold Intolerance Symptom Severity.

4. Discussion

The use of PROs has become a key element in rehabilitation due to their multidimensional nature and ease of administration in clinical practice (Beattie, 2001; MacDermid and Tottenham, 2004; Valdes et al., 2014). The current use of reliable and valid instruments to assess wrist and hand disorders (MacDermid, 1996; MacDermid et al., 1998; Kim et al., 2011) confirms the need for instruments that provide patient perspectives about their disability (Bialocerkowski et al., 2003; Coenen et al., 2013; Dacombe, 2016), that will augment the information obtained from objective sensory and motor evaluations. PROs, including the PRWHE, are known to provide high reliability and validity (Dacombe, 2016).

As hypothesised, the PRWHE was strongly correlated with other PROs. It proved to be a construct-valid measure of long-term nerve repair disability that is quite feasible for clinical practice.

The appearance supplementary question of the PRWHE was less associated with other instruments. Given the favourable recovery of the sample of participants, there were few residual deformities such as residual claw hand or muscle atrophy. More importantly for instrument validation, we did not expect a relationship between aesthetics and function; hence, the findings confirm divergent construct validity.

Nerve injury is known to be a cause of cold intolerance, as indicated by the scores on the CISS questionnaire: these exceeded the population normative values reported by Ruijs et al. (2006). The findings showed that cold intolerance was substantially associated with poorer function on the PRWHE; this provides validation that the PRWHE is capable of measuring the functional impact of this type of impairment. Since most generic or region-specific PROs do not specifically assess cold intolerance, they can only quantify the functional impact, not the intensity of the cold intolerance symptoms. This may explain why the correlation was 0.60, and not higher.

The PRWHE is a PRO that is of particular interest to hand therapists (MacDermid, 2011; Valdes et al., 2014). Its psychometric properties have been confirmed using classic methods (MacDermid et al., 1998, 2007; Wah et al., 2006; Brink et al., 2009) and by Rasch analysis (Packham and MacDermid, 2013). A body of literature on the PRWE has been summarised in a systematic review (Van de Ven-Stevens et al., 2009) that suggests strong performance for the PRWE/PRWHE. This study adds to that body of literature, since properties in a nerve population have not previously been reported.

It was not the purpose of this study to compare the DASH and PRWHE, but the data support the validity of both PROs since they were strongly associated. However, a correlation of 0.8 means that 64% of the variation on one measure was associated with the variation in the other, so the scores should not be considered interchangeable. Data on responsiveness in a nerve recovery population in a head-to-head comparison study would be needed to determine if one PRO outperforms the other.

The PRWHE pain domain had a moderate to high correlation with most subcomponents of the MPQ questionnaire and its total score. Since the PRWHE has a pain subscale, we expected stronger correlations between the pain subscale and the PRO that measured pain. This confirms that the construct of pain is being measured. Pain is an important element in nerve injury; tracking it in a separate subscale is a potential advantage of the PRWHE over the DASH (MacDermid and Tottenham, 2004).

Standardised tools such as the Rosén score provide a more specific assessment of nerve functioning, as might other sensorimotor performance-based tests (Jerosch-Herold, 1993; Novak, 2001; Seftchick et al., 2011). Its subdomains were highly associated with the PRWHE, a finding that supports the latter's construct validity, i.e. that the PRWHE is measuring the disability associated with nerve impairments. Since the Rosén score contains both performance tests and self-reported complaints, it does contain important information distinct from that measured by the PRWHE. In this regard, the two measures can be

Table 2
Pearson correlation (*r*) between total PRWHE and its subcomponents (pain, function, and appearance) and motor, sensory, pain, and functional assessment tools.

		PRWHE							
		Domains							
		Appearance		Pain		Function		Total	
Rosén score	Motor	*r*	**−0.42***	*r*	**−0.66****	*r*	**−0.55****	*r*	**−0.66****
	Sensory	*r*	−0.05	*r*	**−0.44***	*r*	**−0.56****	*r*	**−0.49***
	Discomfort/Pain	*r*	**−0.49****	*r*	**−0.62****	*r*	**−0.58****	*r*	**−0.60****
	Total	*r*	−0.02	*r*	−0.26	*r*	−0.23	*r*	−0.25
DASH		*r*	0.36**	*r*	**0.79***	*r*	**0.82***	*r*	**0.83****
CISS		*r*	**0.49***	*r*	**0.62****	*r*	**0.58****	*r*	**0.60****
MPQ	Sensory discriminative	*r*	0.37	*r*	0.38	*r*	0.32	*r*	0.36
	Motivational affective	*r*	0.20	*r*	**0.45****	*r*	**0.51****	*r*	**0.50****
	Cognitive evaluative	*r*	0.07	*r*	**0.52****	*r*	**0.58****	*r*	**0.61****
	Miscellaneous	*r*	0.30	*r*	**0.54****	*r*	**0.66****	*r*	**0.66****
	Total	*r*	0.30	*r*	**0.53****	*r*	**0.56***	*r*	**0.58****
Motor impairment	Key pinch	*r*	−0.17**	*r*	**−0.45****	*r*	**−0.58****	*r*	**−0.62****
	Tripod pinch	*r*	−0.38**	*r*	**−0.56****	*r*	**−0.66****	*r*	**−0.71****
	Grip	*r*	−0.22**	*r*	−0.59**	*r*	**−0.58****	*r*	**−0.66****
Sensory impairment	SWMF™	*r*	0.07	r	0.40*	r	**0.58****	r	**0.50****
	PSSD™	*r*	0.02	r	0.40*	r	0.31	r	0.36
Dexterity	Large	*r*	029	r	**0.51****	r	**0.48**	r	**0.60****
	Small	*r*	0.17	r	**0.52****	r	**0.51****	r	**0.57****

**Correlation is significant at 0.01 (two-tailed).
*Correlation is significant at 0.05 (two-tailed).
Bold text denotes substantial to high associations ($r \geq 0.45$[59,60]).
Negative values denote an inverse (divergent) relationship between PRWHE total and subcomponents and the instrument scores; positive (convergent) to a direct relationship between disability questionnaire and the instrument scores.

considered complementary.

Another form of construct validity assesses whether measures can discriminate between groups known to be different. For this assessment, we compared a full versus partial nerve laceration, but found no significant difference. However, there are many other factors that affect the severity of a nerve injury. The long-term follow-up minimised the differences between our groups since there was more opportunity for recovery, and the small subgroups reduced the statistical power. These issues may have precluded our ability to have a true test of discriminative (known group validity) in our sample.

The sample in this study was relatively young and mostly male, with an equivalent amount of median and ulnar lesions. This can be considered representative of the population of individuals who generally suffer this type of nerve injury (Jaquet et al., 2001; Rosberg et al., 2005; Fonseca et al., 2006; Trybus et al., 2006; Saadat et al., 2011).

4.1. Clinical implications

The Patient-Rated Wrist and Hand Evaluation (PRWHE) is a simple patient-report outcome scale that, based on our findings, could be an alternative in clinical practice, included in the battery of assessment tests for function domain in nerve repair, with the high prevalence on the hand and wrist.

5. Conclusions

The PRWHE demonstrated construct validity in patients in long-term follow-up of nerve repair based on comparison with other valid impairment and disability outcome measures. Discriminative validity findings were inconclusive, and responsiveness was not evaluated. Thus, while these cross-sectional findings are positive, longitudinal studies are needed.

Conflict of interest

The authors have no conflict of interest to declare.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.msksp.2019.01.007.

References

Amadio, P.C., 2001. Outcome assessment in hand surgery and hand therapy: an update. J. Hand Ther. 14 (2), 63–67.
American Society of Hand Therapists (ASHT), 1992. Clinical Assessment Recommendations, second ed. American Society of Hand Therapists, Chicago.
Angst, F., John, M., Goldhahn, J., Herren, D.B., Pap, G., Aeschlimann, A., et al., 2005. Comprehensive assessment of clinical outcome and quality of life after resection interposition arthroplasty of the thumb saddle joint. Arthritis Rheumatol. 53, 205–213.
Badalamente, M., Coffelt, L., Elfar, J., Gaston, G., Hammert, W., Huang, J., et al., 2013 Feba. American Society for Surgery of the Hand Clinical Trials and Outcomes Committee. Measurement scales in clinical research of the upper extremity, part 1: general principles, measures of general health, pain, and patient satisfaction. J. Hand Surg. Am. 38 (2), 401–406.
Badalamente, M., Coffelt, L., Elfar, J., Gaston, G., Hammert, W., Huang, J., et al., 2013 Febb. American Society for Surgery of the Hand Clinical Trials and Outcomes Committee. Measurement scales in clinical research of the upper extremity, part 2: outcome measures in studies of the hand/wrist and shoulder/elbow. J. Hand Surg. Am. 38 (2), 407–412.
Beaton, D.E., Katz, J.N., Fossel, A.H., Wright, J.G., Tarasuk, V., Bombardier, C., 2001. Measuring the whole or the parts? validity, reliability, and responsiveness of the Disabilities of the Arm, Shoulder and Hand outcome measure in different regions of the upper extremity. J. Hand Ther. 2, 128–146.
Beattie, P., 2001. Measurement of health outcomes in the clinical setting: applications to physiotherapy. Physiother. Theory Pract. 17, 173–185.
Bell-Krotoski, J., 2011. Sensibility testing with the Semmes-Weinstein monofilaments. In: Skirven, T.M., Lee Osterman, A., Fedorczyk, J.M., Amadio, P.C. (Eds.), Rehabilitation of the Hand and Upper Extremity, sixth ed. Mosby, St. Louis Chap. 13.
Bergner, M., Rothman, M.L., 1987. Health status measures: an overview and guide for selection. Annu. Rev. Public Health 8, 191–210.

Bialocerkowski, A.E., Grimmer, K.A., Bain, G.I., 2003. Validity of the patient-focused wrist outcome instrument: does impairment represent functional ability? Hand Clin. 19, 449–455.
Brink, S.M., Voskamp, E.G., Houpt, P., Emmelot, C.H., 2009. Psychometric properties of the patient rated wrist/hand evaluation—Dutch language version (PRWH/E-DLV). J. Hand Surg. 34, 556–557 (European Volume).
Bucher, C., Hume, K.I., 2002. Assessment following hand trauma: a review of some commonly employed methods. Br. J. Hand Ther. 7 (3), 79–84.
Burnand, B., Kernan, W.N., Feinstein, A.R., 1990. Indexes and boundaries for "quantitative significance" in statistical decisions. J. Clin. Epidemiol. 43 1273e84.
Callahan, A.D., 2011. Sensibility assessment for nerve lesions in continuity and nerve lacerations. In: Skirven, T.M., Lee Osterman, A., Fedorczyk, J.M. (Eds.), Rehabilitation of the Hand and Upper Extremity, sixth ed. Mosby, St. Louis Chap. 14.
Carlsson, I., Cederlund, R., Hoglund, P., Lundborg, G., Rosén, B., 2008. Hand injuries and cold sensitivity: reliability and validity of cold sensitivity questionnaires. Disabil. Rehabil. 30, 1920–1928.
Changulani, M., Okonkwo, U., Keswani, T., Kalairajah, Y., 2008. Outcome evaluation measures for wrist and hand: which one to choose? Int. Orthop. 32, 1–6.
Chung, K.C., Pillsbury, M.S., Walters, M.R., Hayward, R.A., 1998. Reliability and validity testing of the Michigan hand outcomes questionnaire. J. Hand Surg. 23, 575–587 [American Version].
Coenen, M., Kus, S., Rudolf, K.D., Müller, G., Berno, S., Dereskewitz, C., et al., 2013. Do patient-reported outcome measures capture functioning aspects and environmental factors important to individuals with injuries or disorders of the hand? J. Hand Ther. 26, 332–342.
Dacombe, P.J., 2016. Patient-reported outcome measures for hand and wrist trauma. Hand 11, 11–21.
De Smet, L., 2008. The DASH questionnaire and score in the evaluation of hand and wrist disorders. Acta Orthop. Belg. 5, 575–581.
Fonseca, M.C.R., Mazzer, N., Barbieri, C.H., Elui, V.M.C., 2006. Hand injuries: a retrospective study. Rev. Bras. Ortop. 41 (5), 181–186.
Gupta, A., Gupta, A.K., Uppal, S.K., Mittal, R.K., Garg, R., Aggarwal, N., June 2012. Demographic profile of hand injuries in an industrial town of North India: a review of 436 patients. Indian J. Surg. 1–8.
Hemelaers, L., Angst, F., Drerup, S., Simmen, B.R., Wood-Dauphinee, S., 2008. Reliability and validity of the German version of "the Patient-rated Wrist Evaluation (PRWE)" as an outcome measure of wrist pain and disability in patients with acute distal radius fractures. J. Hand Ther. 21, 366–376.
Hudak, P.L., Amadio, P.C., Bombardier, C., 1996. Upper extremity collaborative group (UECG). Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand). Am. J. Ind. Med. 29, 602–608.
Imaeda, T., Uchiyama, S., Wada, T., Okinaga, S., Sawaizumi, T., Omokawa, S., et al., 2010. Reliability, validity, and responsiveness of the Japanese version of the patient-rated wrist evaluation. J. Orthop. Sci. 15, 509–517.
Jaquet, J.-B., Luijsterburg, A.J.M., Kalmijn, S., Kuypers, P.D.L., Hofman, A., Hovius, S.E.R., 2001. Median, ulnar, and combined median-ulnar nerve injuries: functional outcome and return to productivity. J. Trauma Inj. Infect. Crit. Care 51, 687–692.
Jerosch-Herold, C., 1993. Measuring outcome in median nerve injuries. J. Hand Surg. 18B, 624–628.
Jerosch-Herold, C., 2005. Assessment of sensibility after nerve injury and repair: a systematic review of evidence for validity, reliability and responsiveness of tests. J. Hand Surg. B 3, 252–264.
John, M., Angst, F., Awiszus, F., Pap, G., MacDermid, J.C., Simmen, B.R., 2008. The Patient-Rated Wrist Evaluation (PRWE): cross-cultural adaptation into German and evaluation of its psychometric properties. Clin. Exp. Rheumatol. 26, 1047–1058.
Johnston, K., Durand, D., Hildebrand, K.A., 2009. Chronic volar distal radioulnar joint instability: joint capsular plication to restore function. Can. J. Surg. 52, 112–118.
Kim, A.H., Pegreffi, F., Ladd, A., 2011. Measuring wrist and hand function: common scales and checklists. Injury: Int. J. Care Inj. 42, 253–258.
Kołodziej, R.K., Blacha, J., Bogacz, A., Mazurkiewicz, T., 2006. Long-term outcome of scaphoid nonunion treated by the Matti-Russe operation. Ortop. Traumatol. Rehabil. 8, 507–512.
MacDermid, J.C., 1996 Apr–Jun. Development of a scale for patient rating of wrist pain and disability. J. Hand Ther. 9 (2), 178–183.
MacDermid, J.C., 2005. Measurement of health outcomes following tendon and nerve repair. J. Hand Ther. 18, 297–312.
MacDermid, J.C., 2011. Outcomes measurement in upper extremity practice. In: Skirven, T.M., Lee Osterman, A., Fedorczyk, J.M., Amadio, P.C. (Eds.), Rehabilitation of the Hand and Upper Extremity, sixth ed. Mosby, St. Louis Chap. 16.
MacDermid, J.C., Richards, R.S., Donner, A., Bellamy, N., Roth, J.H., 2000. Responsiveness of the Short Form-36, Disability of the Arm, Shoulder, and Hand questionnaire, patient-rating wrist evaluation, and physical impairment measurements in evaluating recovery after a distal radius fracture. J. Hand Surg. 25, 330–340 [American Version].
MacDermid, J.C., Richards, R.S., Roth, J.H., 2001. Distal radius fracture: a prospective outcome study of 275 patients. J. Hand Ther. 14, 154–169.
MacDermid, J.C., Roth, J.H., Richards, R.S., 2003. Pain and disability reported in the year following a distal radius fracture: a cohort study. BMC Muscoskelet. Disord. 4 (1), 24.
MacDermid, J.C., Tottenham, V., 2004. Responsiveness of the disability of the arm, shoulder, and hand (DASH) and patient-rated wrist–hand evaluation (PRWHE) in evaluating change after hand therapy. J. Hand Ther. 17, 18–23.
MacDermid, J.C., Turgeon, T., Richards, R.S., Beadle, M., Roth, J.H., 1998. Patient rating of wrist pain and disability: a reliable and valid measurement tool. J. Orthop. Trauma 12, 577–586.
MacDermid, J.C., Wessel, J., Humphrey, R., Ross, D., Roth, J.H., 2007. Validity of self-report measures of pain and disability for persons who have undergone arthroplasty for osteoarthritis of the carpometacarpal joint of the hand. Osteoarthritis Cartilage 15, 524–530.
Mehta, S.P., Mhatre, B., MacDermid, J.C., Mehta, A., 2012. Cross-cultural adaptation and psychometric testing of the Hindi version of the patient-rated wrist evaluation. J. Hand Ther. 25, 65–78.
Mellstrand Navarro, C., Ponzer, S., Törnkvist, H., Ahrengart, L., Bergström, G., 2011. Measuring outcome after wrist injury: translation and validation of the Swedish version of the patient-rated wrist evaluation (PRWE-Swe). BMC Muscoskelet. Disord. 12, 171.
Melzack, R., 1975 Sep. The McGill Pain Questionnaire: major properties and scoring methods. Pain 1 (3), 277–299.
Naidu, S.H., Panchik, D., Chinchilli, V.M., 2009. Development and validation of the hand assessment tool. J. Hand Ther. 22, 250–257.
Novak, C.B., 2001. Evaluation of hand sensibility: a review. J. Hand Ther. 14, 266–272.
Packham, T., MacDermid, J.C., 2013. Measurement properties of the Patient-Rated Wrist and Hand Evaluation: Rasch analysis of responses from a traumatic hand injury population. J. Hand Ther. 26, 216–224.
Pearce, J., Morley, S., 1989. An experimental investigation of the construct validity of the McGill pain questionnaire. Pain 39, 115–121.
Rodrigues, E.K.S., Fonseca, M.C.R., MacDermid, J.C., 2015. Brazilian version of the Patient Rated Wrist Evaluation (PRWE-BR): cross-cultural adaptation, internal consistency, test-retest reliability and construct validity. J. Hand Ther. 28, 69–76.
Rosberg, H.E., Carlsson, K.S., Dahlin, L.B., 2005. Prospective study of patients with injuries to the hand and forearm: costs, function, and general health. Scand. J. Plast. ReConstr. Surg. Hand Surg. 39, 360–369.
Rosén, B., Lundborg, G., 2003. A new model instrument for outcome after nerve repair. Hand Clin. 19, 463–470.
Ruijs, A.C.J., Jaquet, J.-B., Daanen, H.A.M., Hovius, S.E.R., 2006. Cold intolerance of the hand measured by the CISS questionnaire in a normative study population. J. Hand Surg. 31, 533–536 [British Version].
Saadat, S., Eslami, V., Rahimi-Movaghar, V., 2011 Nov. Tehran, Iran. The incidence of peripheral nerve injury in trauma patients in Iran. Ulus Travma Acil Cerrahi Derg 17 (6), 539–544.
Seftchick, J.L., DeTullio, L.M., Fedorczyk, J.M., Aulicino, P.L., 2011. Clinical examination of the hand. In: Skirven, T.M., Lee Osterman, A., Fedorczyk, J.M. (Eds.), Rehabilitation of the Hand and Upper Extremity, sixth ed. Mosby, St. Louis Chap. 6.
Staples, M.P., Forbes, A., Green, S., Buchbinder, R., 2010. Shoulder-specific disability measures showed acceptable construct validity and responsiveness. J. Clin. Epidemiol. 63, 163–170.
Tassler, P.L., Dellon, A.L., July 1995. Correlation of measurements of pressure perception using the pressure-specified sensory device with electrodiagnostic testing. J. Occup. Environ. Med. 37, 862–866.
Trybus, M., Lorkowski, J., Brongel, L., Hładki, W., 2006. Causes and consequences of hand injuries. Am. J. Surg. 192, 52–57.
Turgeon, T.R., MacDermid, J.C., Roth, J.H., 1999. Reliability of the NK dexterity board. J. Hand Ther. 12, 7–15.
Valdes, K., MacDermid, J.C., Algar, L., Connors, B., Cyr, L.M., Dickmann, S., et al., 2014. Hand therapist use of patient report outcome (PRO) in practice: a survey study. J. Hand Ther. 27, 299–308.
Van de Ven-Stevens, L.A., Munneke, M., Terwee, C.B., Spauwen, P.H., van der Linde, H., 2009. Clinimetric properties of instruments to assess activities in patients with hand injury: a systematic review of the literature. Arch. Phys. Med. Rehabil. 90, 151–169.
Voche, P., Dubert, T., Laffargue, C., Gosp-Server, A., 2003. Patient-rated wrist questionnaire: preliminary report on a proposed French version of a North American questionnaire designed to assess wrist pain and function. Rev. Chir. Orthop. Reparatrice Appar. Mot. 89, 443–448 (in French).
Vordemvenne, T., Langer, M., Ochman, S., Raschke, M., Schult, M., 2007. Long-term results after primary microsurgical repair of ulnar and median nerve injuries. A comparison of common score systems. Clin. Neurol. Neurosurg. 109, 263–271.
Wah, J.W.M., Wang, M.K.W., Ping, C.L.T.W., 2006. Construct validity of the Chinese version of the patient-rated wrist evaluation questionnaire (PRWE-Hong Kong version). J. Hand Ther. 19, 18–27.
Wilcke, M.T., Abbaszadegan, H., Adolphson, P.Y., 2009. Evaluation of a Swedish version of the patient-rated wrist evaluation outcome questionnaire: good responsiveness, validity, and reliability, in 99 patients recovering from a fracture of the distal radius. Scand. J. Plast. ReConstr. Surg. Hand Surg. 43, 94–101.
Xu, W., Seow, C., 2003. Chinese version of Patient-Rated Wrist Evaluation (PRWE): cross-cultural adaptation and reliability evaluation. Ann. Acad. Med. Singapore 32 (Suppl. l), S48–S49.