The reliability and validity of the locognosia test after injuries to peripheral nerves in the hand

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Locognosia, the ability to localise touch, is one aspect of tactile spatial discrimination which relies on the integrity of peripheral end-organs as well as the somatosensory representation of the surface of the body in the brain. The test presented here is a standardised assessment which uses a protocol for testing locognosia in the zones of the hand supplied by the median and/or ulnar nerves.

The test-retest reliability and discriminant validity were investigated in 39 patients with injuries to the median or ulnar nerve. Intraclass correlation coefficients were used to calculate the test-retest reliability. Discriminant validity was assessed by comparing the injured with the unaffected hand.

Excellent test-retest reliability was demonstrated for the injuries to the median (intraclass correlation coefficient 0.924, 95% confidence interval 0.848 to 1.00) and the ulnar nerves (intraclass correlation coefficient 0.859, 95% confidence interval 0.693 to 1.00). The magnitude of the difference in scores between affected and unaffected hands showed good discriminant validity. For injuries to the median nerve the mean difference was 11.1 points (1 to 33; SD 7.4), which was statistically significant (paired \( t \)-test, \( p < 0.0001 \)) and for those of the ulnar nerve it was 4.75 points (1 to 13.5; SD 3.16), which was also statistically significant (paired \( t \)-test, \( p < 0.0001 \)).

The locognosia test has excellent test-retest reliability, is a valid test of tactile spatial discrimination and should be included in the evaluation of outcome after injury to peripheral nerves.
Inaccurate localisation of touch or ‘referred’ touch after nerve transection has been widely described and results in diminished tactile gnosis, which is the ability to identify shape, form and texture without vision. Misdirection of regenerated nerve fibres is thought to account for this.\(^7,8\)

The points stimulated on the autonomous zone of an injured nerve no longer match with their central projection and the patient is unable to interpret the altered sensations correctly. Although these aberrant patterns of re-innervation cannot be altered peripherally, the somatotopic representation of the surface of the body can be altered through sensory learning.\(^9,10\) The assessment of localisation is therefore a necessary component in the evaluation of the effectiveness of programmes of formal sensory re-learning.

We now present the standardised protocol for the area localisation test and its theoretical background, and the results of a study of the test-retest reliability and discriminant validity in a group of patients with injuries to the median or ulnar nerves.

**Patients and Methods**

Between July 2003 and February 2005, 39 patients who had undergone surgical repair of the median (23) or ulnar nerves (16) were recruited from two centres for hand surgery. There were 32 males and seven females with a mean age of 40 years (12 to 75). The left hand was injured in 22 and the right in 17 patients. The mean interval between injury and the first assessment was 19 months (6 to 84).

**Development of a standardised protocol for testing locognosia.** The area localisation test uses a grid superimposed on the hand or a drawn map of the hand divided into zones. The subject is asked to identify the zone in which the stimulus is perceived. Localisation charts were first described by Wynn-Parry.\(^11\) More recently, Marsh\(^12\) described a method in which the autonomous territory of the median nerve on the volar surface of the hand is divided into 16 zones of approximately 1 cm\(^2\). A stimulus which is localised correctly is scored as 2 points, if immediately adjacent it is scored as 1 and otherwise zero. This method is based on the studies of healthy volunteers which showed that mislocalisation was most likely to another digit rather than an adjacent segment of the same digit.\(^13\) Such long-range mislocalisations are thought to result from overlapping of the receptive fields for the digit, together with the sequential representation of all digits in the somatosensory cortex.\(^13,14\)

Using the ratio of scores between the affected and unaffected sides a final score of between 0 and 10 is calculated. The distribution of scores in a group of patients with lesions of the median and ulnar nerves\(^12\) was positively skewed and the test was too easy for most, thus displaying a ceiling effect. In Marsh’s version of the test each zone represented a whole finger pulp (to the distal interphalangeal joint). However, the error of localisation in the finger pulps (the volar side distal to the distal interphalangeal joint) of healthy individuals has been found to be 1 mm to 1.5 mm, which is less than one tenth of the whole area and may therefore account for the task being too easy for patients even after nerve injury. Division of the volar surface of the distal phalanx into four zones using an intersecting longitudinal and horizontal axis, gives areas of approximately 0.5 cm\(^2\) to 0.8 cm\(^2\), depending on the size of the digit. This method of test-
ing locognosia was first used in a follow-up of 14 patients with complete and partial injury of the median nerve.\(^1^5\) The distribution of scores using this method was less skewed and the test did not show the effects of flooring or ceiling. The **locognosia test**. A diagram of the hand with a superimposed grid of zones, numbered as shown in Figure 1, is presented to the patient. The patient’s hand is concealed by a screen and well supported to minimise movement of the digits during testing (Fig. 2). The patient is asked to identify the zone where a suprathreshold stimulus has been perceived. The stimulus is delivered using a Semmes-Weinstein monofilament (North Coast Medical, Morgan Hill, California) which upon contact with the skin bends, providing a repeatable peak force of 450 g. Two sites are selected randomly and stimulated using the monofilament. The patient is asked to identify the corresponding zone on the diagram by its number. The first two trials are not scored and serve to clarify that the patient has understood the instructions. The unaffected hand is tested first.

To test the autonomous zone of the median nerve on each hand, each of the 14 zones is stimulated twice in a predetermined randomised order. For the ulnar nerve each of the six zones is stimulated twice in a similar manner.

After a zone has been touched the patient is asked to identify the location of the stimulus by calling out the corresponding number on the diagram. In order to prompt the patient the tester says ‘now’ when the filament contacts the skin. Each stimulus is applied for two seconds followed by an interval of three seconds before the second stimulus.

The number of the zone where the stimulus is perceived is recorded. The method of Marsh\(^1^2\) is used to quantify the ability to localise the stimulus. A score of two points is given for the median zone, nine individuals who are known to have a trait and those who do not. In our case the affected and unaffected hands of the patients were compared. All injuries were unilateral and therefore the unaffected hands were assumed to have normal sensation. In order to assess discriminant validity, the difference in scores between the injured and uninjured hands was considered. The statistical significance between the hands was assessed using a paired \(t\)-test. A \(p\) value < 0.05 was considered significant.

### Results

A summary of the scores obtained is shown in Table I. There appeared to be an increase in the scores between the first and second tests for the area of the median nerve (mean difference 1.74; \(p = 0.020\)), suggesting a slight learning effect, but not for that of the ulnar nerve (mean difference 0.00; \(p = 1.00\)).

The test-retest intraclass correlation coefficient for the median zone was 0.924 (95% confidence interval (CI) 0.848 to 1.00) indicating a very high level of reproducibility. For the ulnar zone it was 0.859 (95% CI 0.693 to 1.00) indicating a very high level of reproducibility.

In the unaffected hands the scores demonstrated a marked ceiling effect with both zones having a very left skewed distribution. For the median zone, nine individuals

<p>| Table I. Locognosia test scores for patients with injuries to the median and ulnar nerves |
|-------------------------------------|-------------------------------------|-------------------------------------|
| <strong>Median nerve zone</strong>              | <strong>Ulnar nerve zone</strong>                |
| (max score 56 points)              | (max score 24 points)               |
| <strong>Mean (sd)</strong>                      | <strong>Mean (sd)</strong>                       | <strong>Median (IQR)(^a)</strong>             |</p>
<table>
<thead>
<tr>
<th>Test 1</th>
<th>Test 2</th>
<th>Unaffected hand</th>
</tr>
</thead>
<tbody>
<tr>
<td>41.7 (9.5)</td>
<td>43.4 (9.3)</td>
<td>53.7 (3.2)</td>
</tr>
<tr>
<td>41 (39 to 49)</td>
<td>45 (41 to 50)</td>
<td>55 (53 to 56)</td>
</tr>
<tr>
<td><strong>Mean (sd)</strong></td>
<td><strong>Median (IQR)(^a)</strong></td>
<td></td>
</tr>
<tr>
<td>Test 2</td>
<td>Unaffected hand</td>
<td></td>
</tr>
<tr>
<td>19.1 (3.9)</td>
<td>19.1 (3.2)</td>
<td>23.8 (0.5)</td>
</tr>
<tr>
<td>19 (17 to 22)</td>
<td>20 (17 to 21)</td>
<td>24 (24 to 24)</td>
</tr>
</tbody>
</table>

\(^a\) IQR, interquartile range
scored the maximum of 56 points and only seven less than 54, with the lowest score observed being 45. For the ulnar zone, only two patients did not score the maximum 24 points, the lowest being 22.

In order to assess the discriminant validity of the locognosia test, the difference between the uninjured hand and the mean of the two test scores for the injured hand was considered. No individual scored lower in their uninjured hand compared with the injured for either zone. For the median zone, the mean difference between the injured and uninjured hands was 11.1 (1 to 33; SD 7.40). This was statistically significant (p < 0.0001) and, compared with the pooled SD within the injured hand, represented an effect size of 1.2. For the ulnar zone, the mean difference was 4.75 (1 to 13.5; SD 3.16), which again was statistically significant (p < 0.0001) with an effect size, based upon the pooled SD of the injured hand, of 1.3.

Discussion

The choice of instruments for measurement and evaluation in rehabilitation should be guided by sound evidence that the test is valid for the intended purpose and population, has an acceptable level of reliability and can reflect clinically important change. Clinical assessments which are undertaken as part of routine patient care need to be cost-effective. The cost of instrumentation, the time taken to administer the test, the ease of scoring and interpretation and the acceptability to the patient are important considerations.

This standardised protocol for testing locognosia in patients with injuries to the median or ulnar nerves yielded high test-retest reliability, but it cannot be assumed that the same degree of reproducibility would be observed in clinicians who are unfamiliar with the test, although the development of a standardised protocol should minimise this. Reliability is not an absolute property. It is population- and condition-specific and therefore caution must be exercised in applying the results of our study to other conditions, such as carpal tunnel syndrome. Also, the study sample was relatively small, especially for the injuries to the ulnar nerve, which would explain the wider CIs of the reliability coefficients.

It has been recommended that a minimum reliability coefficient of 0.70 should be used for research, and coefficients of 0.90 or above when the test is to be used clinically. Others suggest coefficients within a range of 0.50 to 0.70 as indicating moderate reliability, whereas values greater than 0.75 suggest good reliability. If either of these criterion was used here, the locognosia test employed in our study yielded very high reliability coefficients. The test also showed good discriminant validity, as demonstrated by the magnitude of the difference in scores between the injured and uninjured hands in injuries to both the median and the ulnar nerves. The calculated effect sizes are large. In a longitudinal follow-up study reported previously, the locognosia test was found to have good responsiveness in patients with injuries to the median nerve when assessed at six to 18 months after surgery. A large effect (effect size 0.91) was observed and the relative responsiveness of the locognosia test was greater than for the two-point discrimination test (effect size 0.36). The test only requires the use of a monofilament (marked 6.65 on the Semmes-Weinstein Monofilament kit (North Coast Medical) or black filament on the Weinstein Enhanced Sensory Test (Connecticut Bio-instruments, Riverdale, New York)) which is widely used by hand therapists and may already be available in most clinics. It takes only five to ten minutes to complete and although patient acceptability has not been formally assessed there were no adverse reactions or comments made by our patients.

Spatial discrimination may also be assessed by using the two-point discrimination test, which is widely used by surgeons and hand therapists. However, doubts have been raised as to its validity as an absolute measure of spatial threshold and its poor responsiveness, especially in complete nerve lesions. The locognosia test also assesses spatial discrimination and may be a useful adjunct to the two-point discrimination test. It provides a method for assessing spatial discrimination which is valid in patients with injuries to the median and ulnar nerves, has very good repeatability and is sensitive to change over time. It should be considered for inclusion in outcome assessment after peripheral nerve injury.

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