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ORIGINAL RESEARCH

Manual Tactile Test Predicts Sensorimotor Control Capability of Hands for Patients With Peripheral Nerve Injury

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Abstract

Objectives: To comprehend the merits of a Manual Tactile Test (MTT) in assessing hand sensorimotor functions by exploring the relations among 3 subtests along with the precision pinch performances for patients with peripheral nerve injuries (PNIs); and to understand the accuracy of the MTT by constructing the sensitivity and specificity of the test for patients with PNI.

Design: Case-control study.

Setting: Hospital and local community.

Participants: Patients with PNI (n=28) were recruited along with age-, sex-, and handedness-matched healthy controls (n=28) (N=56).

Interventions: Not applicable.

Main Outcome Measures: The Semmes-Weinstein monofilament, moving and static 2-point discrimination, roughness differentiation, stereognosis and barognosis subtests of the MTT, and precision pinch performance were used to examine the sensory and sensorimotor status of the hand.

Results: The worst results in all sensibility tests were found for the patients with PNI ($P<.001$) in comparison with the controls. Multiple linear regression analysis showed the MTT was a better indicator for predicting the sensorimotor capacity of hands in the patients with PNI ($r^2=.189$, $P=.003$) than the traditional test ($r^2=.088$, $P=.051$). The results of the receiver operating characteristic curve estimation show that the area under the curve was .968 and .959 for the roughness differentiation and stereognosis subtests, respectively, and .853 for the barognosis subtest, therefore revealing the accuracy of the MTT in assessing sensorimotor status for patients with PNI.

Conclusions: This study indicates that the MTT is highly accurate and a significant predictor of sensorimotor performance in hands of patients with PNI. The MTT could therefore help clinicians obtain a better understanding of the sensorimotor and functional status of the hand with nerve injuries.

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Laceration injuries to the axons and trunks of peripheral nerves result in axonal degeneration in the distal portion of the nerve from the laceration site. Patients experience impairments in sensory and motor functioning for a period of time before the axons have regenerated to the target receptors, even if the injured nerve has been reconstructed.[1] Recent studies have also reported that the problems of nerve dysfunction of the hands include deficits of sensory function, sensorimotor control, and hand manipulation.[2,3] Because hand functions are severely affected in peripheral nerve injuries (PNIs), hand clinicians need to evaluate the performance of people with PNI and provide a suitable management program.[4,5] However, the actual functional recovery of injured hands still cannot be determined

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objectively using the tools currently applied in clinical practice.[6,7]

The 2-point discrimination and manual muscle tests are used clinically to evaluate sensory nerve function and classify motor nerve function, respectively.[8] These assessments, however, do not provide sufficient information about the clumsy performance of the hands for patients with nerve injuries, even if their muscle strength is still normative.[9] A precision pinch experimental model which analyzes the ability to adjust pinch force corresponding to changes in the inertial load during a lifting task has been used to assess sensorimotor control of the hand after nerve injury.[10,11] A recent study also showed that patients with nerve repair had improvements in the precise force adjustment of the hand during a pinch-holding-up activity (PHUA) as nerve regeneration progressed.[2] In fact, a close correlation has been reported between sensorimotor control and actual hand functioning.[12] The precision pinch experimental model is therefore of clinical significance for the evaluation and rehabilitation of hand functions of patients with PNI.[13]

Although a growing body of literature shows that the delicate sensorimotor control of the hand could be an outcome indicator for the treatment of nerve injuries in the hands,[14,15] the lack of suitable apparatuses for assessing precision pinch performance has forced clinicians to find alternative tools which can be easily implemented in a clinical setting to detect the sensorimotor control capability of a hand. The Manual Tactile Test (MTT) is a new tool that can be used to achieve this, and it shows both high reliability and validity with regard to evaluating the integrated abilities of the hand in perceiving an object's characteristics.[16] The MTT is split into 3 components, namely barognosis, roughness differentiation, and stereognosis, which together provide comprehensive information about the physical properties of an object (eg, weight, texture, shape). The patients use a 2-stage sequence, a general grasping stage and a more precise exploratory process, to extract the underlying properties of objects when conducting the MTT. Because several studies have indicated that tactile acuity relies heavily on gathering sensory information from active hand exploration, the MTT can be an objective assessment for understanding hand sensibility functioning.[17-19]

A recent study demonstrated that the MTT is a valid tool for assessing sensibility and sensorimotor performance and determining functional deficits of the hands in patients with carpal tunnel syndrome.[20] However, the feasibility of applying this tool in clinical practice to assess the sensorimotor function of patients with peripheral nerve repair has not been conclusively verified. The specific aim of this study was therefore to explore the merits of this test with regard to describing the sensorimotor function of hands by analyzing the relation between the results of the MTT along with the precision pinch performance in patients with PNI. In addition, to assess the accuracy of the MTT, the second aim of this work was to evaluate the sensitivity and specificity of the test for patients with PNI.

List of abbreviations:

AUC	**area under the curve**
M2PD	**moving 2-point discrimination**
MTT	**Manual Tactile Test**
PHUA	**pinch-holding-up activity**
PNI	**peripheral nerve injury**
ROC	**receiver operating characteristic**
S2PD	**static 2-point discrimination**
SWM	**Semmes-Weinstein monofilament examination**

Methods

Participants

Study participants included the patients who suffered from PNIs in the hand along with healthy participants matched by age, sex, and handedness. The inclusion criteria for the patients included the following: digital nerve injury to the thumb and index finger, median nerve injury that was distal to the wrist level, or nerve combined tendon injury of the thumb and index finger or digital replantation. The data collection for those patients with pure nerve injury was carried out at least 6 weeks after the operation. For those whose nerve injury was combined with tendon injury, the period between surgery to assessment was >12 weeks to ensure that sufficient tensile strength of the injured tendon was obtained. However, patients with other neurologic or musculoskeletal problems in the upper extremities, hand skin deficits, or diabetes mellitus were excluded. The recruited patients were right-handed in their premorbid status. The sample size was estimated before the experiment was conducted. To detect a meaningful difference between subjects with PNI and healthy controls, at least 27 participants would be needed in both groups using an estimate with a 2-tailed α of .05 and power of .80, according to a previous work.[14] A total of 28 patients with PNI who met the inclusion criteria were therefore recruited. The same number of age- and sex-matched healthy subjects were recruited as the controls through posting advertisements online and on notice boards. The healthy participants did not have any sensory or motor disturbances in the hands which would affect hand functioning. The demographic and clinical characteristics of both groups are listed in table 1. Of the 28 patients who suffered from unilateral PNI, 5 had simple digital nerve injury, 8 had median nerve injury, and 15 had a combination of digital nerve and tendon repair. The mean time since injury to evaluation was 16.4±7.6 weeks. All participants were informed of the purpose of this study and signed consent forms approved by the hospital's institutional review board.

Instruments

Manual Tactile Test

The MTT is used to assess the abilities of roughness differentiation, stereognosis, and barognosis.[16] Before conducting the test, each subject was told to sit on a chair with their hands supported on the table. They were instructed to carry out the tests with the thumb and index and middle fingers as quickly as possible. For each of the subtests, the dominant hand was tested first. The same procedures were then executed for the nondominant hand. The testing procedures of the MTT were repeated 3 times for each hand, with a 1-minute resting interval between trials. The apparatus (fig 1A–C) and details of testing procedures (fig 1D) are shown in table 1.

PHUA test

The PHUA test was conducted with a pinch apparatus (weight, 480g)[21] (fig 2A). It consists of two 6-axis load cells (force/torque transducers[a]) and an accelerometer (model 2412[b]) to record the pinch force and acceleration of the pinch device, respectively,