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# Determining the functional sensibility of the hand in patients with peripheral nerve repair: Feasibility of using a novel manual tactile test for monitoring the progression of nerve regeneration

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ABSTRACT

*Study Design:* Case-controlled cohort study.
*Introduction:* Sensory function is difficult to observe during nerve regeneration processes. Traditional sensory tests are limited to identifying the level of functioning hand sensation for sensory stimulus is given passively to the cutaneous surface of the hand.
*Purpose of the Study:* To examine the outcome changes in the manual tactile test (MTT), Semmes–Weinstein monofilament (SWM) and 2-point discrimination (2PD) tests for patients with nerve repair and to investigate the concurrent validity of MTT by comparing it with the results of traditional tests.
*Methods:* Fifteen patients with nerve injury of the upper limbs were recruited, along with 15 matched healthy controls. The MTT, SWM, and 2PD tests were used to examine the sensory status of the subjects.
*Results:* Three subtests (barognosis, roughness differentiation, and stereognosis) in MTT showed that the patients improved with time. A moderate and mild correlation was found between the MTT and 2PD results and between the barognosis and SWM results.
*Conclusions:* The MTT provides practical and functional perspectives on detecting nerve progression during the courses of degeneration and regeneration.
*Level of Evidence:* IV.



## Introduction

Injuries to the peripheral nerves result in sensory and motor function deficits related to the discontinuity of axons and nerve fibers distal to the lesion site.[1] Once the nerve is repaired, the degenerative and continuum regenerative processes of anatomic and physiological functioning are a concomitant response to nerve injury.[2] During the period of denervation, the patients may experience deficits of muscle weakness and anesthesia. However, unlike muscle strength, sensibility is usually poor after nerve repair because the regeneration of sensory nerve fibers is imperfect, in spite of advances in surgical instruments and techniques.[3] That is, patients may experience a long period of deafferentation after nerve repair. As previous investigations[4,5] reported, both the functioning and social participation of patients may be profoundly impacted by this.

Because peripheral nerve regeneration is a long-term and highly dynamic process, a valid and reliable test for monitoring the actual

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status of the nerve function is crucial for clinicians to determine appropriate patient-centered treatment plans. Traditional assessments of sensibility after nerve injury and repair include the touch-pressure threshold, vibration thresholds, and static and moving 2-point discrimination (S2PD and M2PD) tests.[6,7] Nevertheless, most of these tests are of limited use with regard to helping clinicians identify the functioning level of sensation in hands with sensory deficits.[8,9]

When executing a sensory screening test as part of routine practice, a stimulus is applied to the cutaneous surface of a hand, and then the patient will be asked to reply *yes* or *no*, depending on whether they feel anything. In fact, research has shown that the transmission of tactile input is diminished, and sensory data cannot be efficiently acquired when the sensory stimulus is being provided during a traditional sensory test.[10,11] As the hand serves both executive and perceptual functions,[12] active touching can be used to achieve the entire sensation-perception-action loop and thus optimize movement of the hand.[13,14] Numerous studies[15–17] have documented that people can refine and interpret sensory information more precisely through a self-generated movement. Furthermore, using the results of active hand sensation could also lead to better predictions for hand performance than the results of traditional sensibility assessments.[18] To achieve this, a new manual tactile test (MTT) was developed to evaluate this synthesizing sensibility through the manual exploration of a hand.[19]

Previous studies have reported the high testing reliability, validity, and accuracy of the MTT for carpal tunnel syndrome (CTS) patients.[18,19] However, the recovery and treatment patterns may vary depending on what types of nerve injury patients have. Different to CTS, patients with peripheral nerve injury might experience the clinical pattern of anesthetics and an altered somatosensory profile. The recent literature has noted that advances in the measurement of outcomes enable us to better understand the results of treatment for peripheral nerve injury, including the impacts on functioning, disability, and health.[20] Therefore, in addition to the traditional sensibility tests, the development and use of more functional and objective sensory tests for understanding treatment outcomes have been strongly recommended. To better understand the feasibility of using MTT to monitor nerve regeneration after peripheral nerve repair, the first aim of this study was thus to examine the outcome changes in MTT and traditional sensory tests for patients with peripheral nerve repair during the follow-up period. The second purpose was to investigate the concurrent validity of the MTT by determining the relationship between the results of the traditional sensibility tests and the MTT for patients with nerve repair.

## Methods

### *Participants*

The participants included patients with sensory deficits and controls matched by age, gender, and handedness. The patients suffered 1 of the following injuries: (1) digital nerve injury to the thumb and index finger, (2) median nerve injury that was distal to the wrist level, or (3) digital replantation or toe-to-hand transplantation. Inclusion criteria included sufficient tensile strength of the nerves and tendons to carry out hand manipulations. All the recruited patients received standardized rehabilitation regimes comprising a minimum of 1 hour of occupational and physical therapies for the motor and sensory deficits. The initial evaluation of the participants was performed at least 6 weeks after the operation. However, subjects who had diabetes mellitus, musculoskeletal problems in the upper extremities, hand skin deficits, and other neurologic deficits or previous hand injuries were excluded from this study. In addition, the same number of healthy control subjects was recruited from the local community as our control group, by posting advertisements online and on notice boards, and then matched according to age, sex, and handedness. The participants in the control group did not have any sensory disturbances, neurologic deficits, and musculoskeletal disorders in the hands, or other conditions that may affect hand functioning. All participants were informed of the purpose of this study and signed consent forms approved by the Hospital's Institutional Review Board.

### *Experimental procedures*

This study was an assessor-blinded one with a series of follow-up assessments over 12 weeks. The subjects received evaluations using the traditional sensibility tests and MTT every 6 weeks to detect sensibility improvements and changes in the results of MTT during the course of nerve regeneration. One certified occupational therapist conducted the examinations. The sequence of testing was randomized to minimize potential order effects in this study.

### *Instruments*

#### *Manual tactile test*

The MTT,[19] which consists of 3 subtests, is designed to assess how well a subject can discriminate the distinctive characteristics of the weight (barognosis test), roughness (roughness discrimination test), and shape (stereognosis test) of an object with the active touch of the hand (Fig. 1). Because of its standard testing apparatus and procedures (proposed by Hsu et al, 2013[19]), the MTT has demonstrated high test–retest reliability, good validity, and diagnostic sensitivity[18] for CTS patients.

The MTT consists of the following tests: (1) *Barognosis test*. Three plastic cylinders of an identical size but different weights, 150, 225, and 300 g, are used to test the weight perception of the hand. (2) *Roughness differentiation test*. Plastic cubes (with sides of 2.5 cm) covered of 3 different levels of roughness are used to detect the roughness perception. Six cubes are used for each roughness, for a total of 18 cubes. (3) *Stereognosis test*. Shape perception is tested with 3 different geometric objects, cubes, ellipsoids, and spheroids, which are made of plastic, and have the same weight and roughness. Each configuration consists of 6 objects, with 18 objects in total.

*Testing procedures used with the MTT.* Before conducting the test, all subjects sat upright with their hands supported on the table and were instructed to carry out the tests using their thumb, index, and middle finger. All subjects were asked to perform the test 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 3 subtests were executed with the following standardized procedures. (1) *Barognosis test*. Three cylinders were placed randomly in a line in front of the subject. When starting, each subject was administered the barognosis test with the dominant hand picking up and then placing the cylinder in front of the original location. When the subject had moved all 3 cylinders, they pointed out the heaviest one. (2) *Roughness differentiation test*. Two boxes and 18 cubes were used in the subtest. To block the subject's view, a curtain was placed between them and the testing apparatus. Eighteen cubes were randomly placed inside the right box before