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Ultrasonographic median nerve changes under tendon gliding exercise in patients with carpal tunnel syndrome and healthy controls

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ABSTRACT

Study design: Case control study.
Purpose of the study: To evaluate the ultrasonographic median nerve changes under tendon gliding exercise in patients with carpal tunnel syndrome (CTS) and healthy controls.
Methods: Seventy-three patients with CTS and 53 healthy volunteers were consecutively recruited. Each subject underwent a physical examination, nerve conduction studies and ultrasonographic examinations of the median nerve during tendon gliding exercises.
Results: Significant changes in the cross-sectional area of the median nerve were found while moving from the straight position to the hook position and from the hook position to the fist position. There were also significant changes in the flattening ratio when moving from the hook position to the fist position.
Conclusions: Ultrasonography revealed that the median nerve was compressed in the fist position in both CTS patients and healthy volunteers. Thus, forceful grasping should be avoided during tendon gliding exercises performed in the fist position.
Level of evidence: 3b

Introduction

Carpal tunnel syndrome (CTS) is one of the most common entrapment neuropathies and the pathogenesis of idiopathic CTS is proposed to involve the increased pressure within the carpal tunnel arising from non-inflammatory tenosynovial swelling.[1,2] Histological studies have also demonstrated non-inflammatory fibrosis and thickening of the subsynovial connective tissue, which lies between the flexor tendon and the ulnar tenosynovial bursa inside the carpal tunnel.[3] The median nerve and the flexor tendons are connected by this multilayered subsynovial connective tissue. However, in patients with CTS, this connective tissue is thickened, which may restrict the gliding of the median nerve on both the transverse and longitudinal planes and induce continual trauma, even under normal movement of the limb.[4,5]

To reduce adhesions inside the carpal tunnel, tendon and nerve gliding exercises have been utilized as a component of combination treatments for CTS.[6–8] These exercises are expected to improve the symptoms by stretching the adhesions inside the carpal canal, reducing tenosynovial edema, improving venous return from the nerve bundles, and reducing pressure inside the carpal tunnel.[6,9] Although the therapeutic effects of these exercises remain inconclusive,[6–8,10,11] one previous study revealed that the functional improvement experienced by CTS patients when tendon gliding exercises were added to a standard treatment program was superior to the improvement following the addition of nerve gliding exercises.[12] Meanwhile, the excursion of the flexor digitorum superficialis and profundus tendons is nearly five times greater than that

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of the median nerve.[6,13] It is possible that tendon gliding exercises may redistribute the point of maximal compression on the median nerve inside the carpal canal by bringing the median nerve through its maximal excursion. Understanding the mechanism by which tendon gliding exercises affect the morphological change of median nerve could improve the clinical application of these exercises.

Although ultrasonography has been widely applied to evaluate the median nerve in patients with CTS,[14–16] few studies to date have evaluated the effects of tendon gliding exercises on the morphology of the median nerve. This study used commonly used ultrasonographical criteria, i.e., the cross-sectional area (CSA) and the flattening ratio (FR) of the long axis of the median nerve to the short axis, to evaluate the median nerve. Increases in the CSA and the FR of the median nerve have been demonstrated in patients with CTS, most likely as a result of swelling and compression of the median nerve under the transverse carpal ligament.[15,16]

Purpose

To obtain a better understanding of the dynamic changes of the median nerve during tendon gliding exercises, this study evaluated, by ultrasonography under rest and in five discrete positions of tendon gliding exercises, the morphological changes of the median nerve in patients with CTS and healthy volunteers.

Methods

This study consecutively recruited patients with CTS from the clinic of the physical medicine and rehabilitation department of a community hospital between October 2008 and December 2010. Healthy volunteers were recruited from the hospital staff and included volunteers and their friends. All of the subjects were invited to participate in the study on an entirely voluntary basis, and informed consent was obtained from each of the participants. Ethical approval to undertake this study was provided by our institutional review board. To be included, the patients were required to have: (1) subjective symptoms of tingling and/or numbness within the digits innervated by the median nerve, (2) either a positive Phalen sign or a positive Tinel sign, and (3) electrophysiological evidence of CTS from a nerve conduction study (NCS). The inclusion criteria for healthy volunteers included: (1) neither tingling nor numbness within the digits innervated by the median nerve, (2) both a negative Phalen sign and a negative Tinel sign, and (3) no electrophysiological abnormalities in the NCS of bilateral upper extremities. The exclusion criteria included the following conditions: (1) age <18 or >65 years; (2) cognitive disorders (e.g., mental retardation or dementia); (3) underlying medical disorders such as diabetes mellitus, renal failure, rheumatoid arthritis, hypothyroidism or other autoimmune diseases; and (4) pregnancy or previous wrist trauma or surgery.

The participants were asked to rate their pain intensity on a 0–100 visual analog scale. Every participant was submitted to a nerve conduction study (NCS) of the upper extremities and a series of physical examinations, which included Phalen sign, Tinel sign, the grasp/pinch strength test, and the Semmes-Weinstein monofilament sensory test. Sonography was performed on both wrists at rest and in five positions during the tendon gliding exercise.

Physical examinations

Phalen sign was conducted by fully flexing the patient's wrist for 60 s. The test was positive if the patient's symptoms in the median nerve distribution were reproduced.[17] Tinel sign was evaluated by tapping the median nerve along its course across the wrist. The test was positive if the patient experienced paresthesia in at least one of three radial digits.[17] Grip strength was measured using a handheld dynamometer, and palmar/lateral pinch strength was measured using a standard dynamometer between the tips of the thumb and the index finger. Each participant performed three recorded trials, and the mean score was recorded. The Semmes–Weinstein monofilament sensory test was conducted by applying force-calibrated monofilaments to each digit of the hand. A test was considered to be positive if the subject could verbally localize the digit that was receiving pressure with closed eyes, and a weighted score (1–5) was given to each filament according to the calculated force.[18] Scores obtained from seven sampling areas on each hand were totaled, and this total was analyzed as a continuous variable.

Nerve conduction study

All of the participants underwent median and ulnar nerve sensorimotor NCS utilizing Neuropack M1 MEB-9200 J/K electrodiagnostic equipment (Nihon Kohden Corporation, Tokyo, Japan) in a quiet, air-conditioned room (26 °C), with the subjects lying comfortably. The skin temperature on the hand was maintained higher than 32 °C. Standard techniques of supramaximal percutaneous stimulation, with a constant current stimulator and surface recordings, were used for NCS, as recommended in the literature.[19] At least one of the following criteria had to be met to confirm a clinical diagnosis of CTS: distal motor latency greater than 4.4 ms; distal sensory latency greater than 3.4 ms[20]; or a median-ulnar distal sensory latency difference, stimulated from the ring finger (ring difference), of greater than 0.4 ms.[21]

Tendon gliding exercises

The tendon gliding exercises were initially developed to reduce the adhesion of flexor tendons following trauma or surgery to the hand and wrist.[22,23] As shown in Fig. 1, the tendon gliding exercises used in this study involved sliding the flexor tendons of the hand by moving the fingers through five discrete positions: straight, hook, fist, tabletop, and straight fist positions.[23]

Ultrasonography

Ultrasonography was performed using a 12 MHz linear array transducer (GE LOGIQ 9, General Electric Medical Systems,

Fig. 1. The setup for ultrasound examination. The tested arm was positioned with the help of a wrist orthosis to ensure forearms supinated and wrists in neutral posture.