Altered Median Nerve Deformation and Transverse Displacement during Wrist Movements in Patients with Carpal Tunnel Syndrome

Yuexiang Wang, M.D., Anika Filius, M.D., Sandra Passe, Chunfeng Zhao, M.D., Andrew R. Thoreson, M.S., Kai-Nan An, Ph.D., Peter C. Amadio, M.D..
Mayo Clinic, Rochester, MN, USA.

Disclosures:

Introduction: Carpal tunnel syndrome (CTS) is the most common peripheral nerve entrapment syndrome. Strong pinch or grip with wrist flexion has been considered a risk factor for CTS. Studying median nerve displacement during wrist movements may provide useful information about possible changed median nerve motion patterns in CTS patients. The purpose of this study was to evaluate the deformability and mobility of the median nerve at the proximal carpal tunnel during the wrist movements in CTS patients and compare these results to those of healthy subjects.

Methods: Dynamic ultrasound images were obtained in 20 affected wrists of 13 patients with CTS and in both wrists of 10 healthy subjects during finger and wrist movements. To study the transverse movement of the median nerve in the carpal tunnel, dynamic cross-sectional images at the proximal carpal tunnel were obtained with ultrasound. Initial and final median nerve shape and position were assessed for six defined wrist movements. Deformation ratios resulting from each movement were defined as the median nerve area, perimeter and circularity of the final image normalized by respective quantities assessed in the initial image. Median nerve displacement was defined as the change in its centroid coordinates, in ulnar-radial (x) and palmar-dorsal (y) directions, between the first and final images of each motion sequence. The deformation ratios, displacement magnitude and bivariate vector data were compared between the CTS patients and healthy subjects. The t-test was used to analyze the differences in deformation ratios and normalized displacement amplitude of the median nerve between patients and healthy subjects. The bivariate Mardia’s two-sample test and the Mardia-Watson-Wheeler non-parametric test were used for the comparison of the median nerve displacement vector between patients and healthy subjects.

Results: The deformation ratio for circularity was decreased in CTS patients compared to healthy subjects during wrist flexion with finger flexed, wrist flexion with finger extended and ulnar deviation (P=0.0094, 0.0038 and 0.0002, respectively). In addition, the displacement magnitude of the median nerve was found to be less in CTS patients compared to healthy subjects during wrist flexion - with fingers both flexed and extended - and ulnar deviation (all P<0.05). The mean median nerve displacement vector was significantly different between CTS patients and healthy subjects during wrist flexion -with fingers both flexed and extended-, wrist ulnar deviation and wrist extension with finger extended (P<0.05) (Figure 1).

Discussion: Associations have been made between repetitive hand and wrist motions and the possible effect on the development of CTS. In this study, we found that with maximal wrist flexion with or without fingers flexed and maximal ulnar deviation, the median nerve deformed less in patients with CTS compared to healthy subjects. The normal median nerve deforms to accommodate finger or wrist movement, possibly related to the specific internal structure of median nerve. Histologically, the median nerve is composed of axons, which are bundled by several connective tissue layers. The extensibility of these layers is critical for the nerve to accommodate tensile or compressive stress by elongating, gliding or deforming. In CTS, progressive fibrosis has been found in the epineural and perineural connective tissues. This fibrosis may result in a permanently decreased compliance of the median nerve during its movement within the carpal tunnel. Orman et al. used ultrasound elastography to evaluate the stiffness of median nerve in the carpal tunnel. They found that the median nerve was stiffer in patients with CTS than in normal subjects, which is consistent with the results of our study. We also observed that the mobility of the median nerve was decreased in CTS patients. In the healthy carpal tunnel, the tendons and nerve are surrounded by subsynovial connective tissue (SSCT), which is filmy and supple, and thus can facilitate smooth gliding and deformation of the median nerve. In CTS patients, this tissue is often fibrotic. This may cause the median nerve and tendons to become attached to adjacent structures, preventing the nerve from moving freely and causing it to become compressed between tendons and the flexor retinaculum during wrist flexion. This may explain why CTS symptoms are provoked by Phalen’s maneuver. The reason for the decreased median nerve deformation and displacement magnitude in CTS patients during wrist flexion and not wrist extension may be related to changes of the anatomy or pressure within the carpal tunnel that this particular motion causes which inhibits nerve motion. In wrist flexion both the proximal and distal carpal tunnel cross-sectional areas are decreased compared to the neutral position. Furthermore the flexor tendons move palmarly with wrist flexion. Palmar movement of the flexor tendons may further contribute to increased contact pressure on the median nerve.

Our study has several limitations. First, the study sample size is small. Yet even with this small sample size we were able to detect significant differences between CTS patients and healthy subjects for some parameters. The small sample size also inhibits our ability to correlate ultrasonographic results with the CTS severity. Future studies with larger sample size are
necessary to explore the relationship between the mobility and deformability of the median nerve and the CTS severity; data presented here will serve as a useful baseline. Second, although we collected dynamic ultrasound data, we only analyzed the median nerve in the first and final frames of the movement. However, measurement of median nerve parameters in the first and last frames is a simple method for evaluating the mobility and deformability of the median nerve during wrist movement.

**Significance:** This study has revealed differences in median nerve transverse kinematics in the carpal tunnel between CTS patients and healthy subjects. These results provide baseline knowledge for further investigation of techniques for using the changed median nerve kinematics to select the most appropriate treatment for CTS patients.

**Figure Legend:**
Figure 1. The median nerve displacement vectors in CTS patients and normal subjects during wrist flexion with finger flexed. The radial line represents the mean vector for each group. Solid ellipses represent standard deviation, dashed ellipses represent 95% confidence limits.

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**References:**

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