CARPAL ARCH COMPRESSION DECREASES MEDIAN NERVE FLATTENING IN CARPAL TUNNEL SYNDROME PATIENTS

Tamara L. Marquardt, Peter J. Evans, William H. Seitz, Jr., Zong-Ming Li

Hand Research Laboratory, Departments of Biomedical Engineering, Orthopaedic Surgery, and Physical Medicine and Rehabilitation, Cleveland Clinic, Cleveland, OH, USA
email: liz4@ccf.org, web: http://www.handlab.org

INTRODUCTION

The carpal tunnel in the wrist is formed by the interconnected carpal bones and the transverse carpal ligament (TCL). The tunnel contents include the median nerve, which is susceptible to entrapment in the space-limited tunnel leading to carpal tunnel syndrome (CTS). CTS patients have increased flattening of the median nerve which is alleviated after surgically transecting the TCL to increase carpal tunnel space and decrease tunnel pressure [1]. Recent studies support that the carpal tunnel space can be augmented by narrowing the carpal arch width [2-4]. Furthermore, it has been shown that applying radioulnar compression to the wrist decreases median nerve flattening in asymptomatic controls [4]. However, the implications of wrist compression on the carpal tunnel and median nerve in CTS patients have not been examined. Therefore, the purpose of this study was to investigate the morphological changes of the carpal arch and median nerve in response to wrist compression in CTS patients.

METHODS

Five (n=5) female volunteers diagnosed with CTS (54.6±7.5 years; 4 right, 1 left) participated in this study. Each patient placed the arm in a custom compression system, palm side facing up (Fig. 1). The system applied radioulnar compressive forces of 10 N and 20 N across the distal carpal tunnel level for 3 minutes and then three cross-sectional ultrasound images at this level were acquired. Three unloaded (0 N) ultrasound images were also captured prior to each force application. Each force condition was repeated four times in a randomized order. A 5-minute rest was provided between consecutive trials.

The three unloaded (0 N) and three loaded (10 N or 20 N) ultrasound images from one trial for each load condition were analyzed. ImageJ was used to determine the coordinates of the most volar point of the hook of hamate and the ridge of trapezium, as well as the volar boundary of the TCL. Additionally, ImageJ was used to trace the median nerve’s border and calculate its shape descriptors including perimeter, area, and flattening ratio (major axis/minor axis of fit ellipse). The ImageJ coordinates were transformed into an anatomically relevant coordinate system, and carpal arch width (CAW) and carpal arch area (CAA) were calculated. CAW was defined as the distance between the hamate and trapezium. CAA was the area bounded by the volar TCL boundary and the CAW line.

One-way repeated measures ANOVAs were performed to investigate the effect of force magnitude (0, 10, and 20 N) on CAW and CAA, as well as the median nerve’s perimeter, area, and flattening ratio. Post-hoc Tukey’s tests were used for pairwise comparisons and p<0.05 was considered statistically significant.
RESULTS AND DISCUSSION

Ultrasonography captured changes of the carpal arch and median nerve in response to compressive force applied across the wrist of CTS patients (Fig. 2). CAW and the nerve’s flattening ratio were significantly affected by force (p<0.01).

![Figure 2](image)

Figure 2: Representative images at 0, 10, and 20 N with the hamate (HH, #), trapezium (TM, +), TCL boundary (dotted line), and nerve (solid line) identified.

Specifically, CAW decreased by 0.9±0.5mm with 10 N of applied force and by 2.0±1.3mm with 20 N of force, relative to the initial CAW of 22.7±2.4mm at 0 N (Fig. 3). Pairwise comparisons revealed a significant difference between CAW at 0 N and 20 N (p<0.01). Although CAW decreased, CAA remained relatively constant (17.6±6.2mm² at 0 N) when compressive forces were applied (17.4±6.6mm² at 10 N and 18.2±5.6mm² at 20 N), and the changes were not statistically significant (p=0.88).

![Figure 3](image)

Figure 3: Carpal arch width (CAW) at force magnitudes of 0, 10, and 20 N. *p<0.01

Force did not significantly affect the nerve’s perimeter (p=0.07) or area (p=0.68) which were initially 16.3±0.9mm and 11.1±1.3mm², respectively. However, the nerve’s shape became more round (Fig. 4) as reflected by decreases in its flattening ratio with force application (p<0.01). The flattening ratio of the nerve was 3.90±0.79 at 0 N, and it decreased by 0.54±0.57 at 10 N and by 1.06±0.44 at 20 N. Pairwise comparisons found that the flattening ratio was significantly different between 0 N and 20 N (p<0.01).

![Figure 4](image)

Figure 4: Median nerve outlines for individual patients at 0, 10, and 20 N with the dashed line indicating the average fit ellipse.

This study revealed that radioulnar compressive force applied across the wrist affected the morphology of the carpal arch and the median nerve in CTS patients. Previous studies have demonstrated that CAW can be narrowed [2, 3], and that this narrowing can be achieved in vivo [4]. The changes in CAW of CTS patients from wrist compression in the current study agree with the findings from a previous study with control subjects [4]. Even though CAA did not increase with force application, flattening of the median nerve decreased. It has been shown that the nerve undergoes shape changes to minimize insult within the tunnel space [5]. Nerve flattening in CTS patients also decreases after carpal tunnel release surgery. Therefore, radioulnar wrist compression may provide relief of nerve compression in patients with CTS.

REFERENCES


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