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ORIGINAL ARTICLE

Ultrasound Evaluation of the Normal Ulnar Nerve in Guyon's Tunnel: Cross-sectional Area and Anthropometric Measurements

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Abstract *Background:* Ulnar nerve (UN) entrapment is an infrequent disorder, but is often seen in long-distance cyclists. Electrodiagnosis and imaging modalities, including ultrasound, are used for diagnosis. The goal of this study was to obtain sonographic normative data of the UN in Guyon's tunnel, to establish the diagnosis of Guyon's tunnel syndrome in future studies. Anthropometric measures were also obtained.
Methods: A total of 46 healthy volunteers (30 men) were recruited (mean age, 24.7 ± 3.1 years), and a total of 83 wrists were examined. The examinations included anthropometric measurements (wrist width, wrist depth, wrist circumference, palm length, and hand width) and ultrasound measurement of the cross-sectional area (CSA) of the UN in Guyon's tunnel. B-mode sonography and power Doppler were employed.
Results: The UN CSA in Guyon's tunnel for male volunteers was 6.0 ± 2.0 mm^2, and 5.0 ± 1.0 mm^2 for female volunteers. There was a significant difference between female and male volunteers in the measurements of wrist width, wrist depth, wrist circumference, palm length, hand width, and UN CSA ($p < 0.001$). The UN CSA was correlated with wrist width, wrist depth, wrist circumference, palm length and hand width ($p < 0.01$). Differences were noted within and between gender groups of UN CSA within Guyon's tunnel.
Conclusion: Nerve CSA may differ by gender and this may be related to body size. Therefore, the contralateral side is more useful as a reference standard than the gender mean.

Conflicts of interest: The authors declare no financial or nonfinancial conflicts of interest that would in any manner affect the collection, analysis, or interpretation of data.

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Introduction

The annual incidence of upper extremity cumulative trauma disorders ranges from 21.1% to 25.3% in industrial and clerical occupations [1,2], and carpal tunnel syndrome and cubital tunnel syndrome are the two most common conditions. Ulnar nerve (UN) entrapment at Guyon's tunnel is far less frequent, estimated to be one-twentieth of that occurring at the cubital tunnel [3]. The exact prevalence of Guyon's tunnel syndrome is unknown due to limited existing studies. Despite the low prevalence among the general population, the prevalence of UN entrapment in Guyon's tunnel, referred as "cyclist's palsy" or "handlebar palsy" seems to be relatively common among long-distance cyclists. Patterson et al [4] reported that 36% of cyclists ($n = 25$) experienced UN symptoms after a long-distance race. Thus, although the prevalence of UN entrapment at Guyon's tunnel might be low in the general population, in certain groups, where there is prolonged compression on the wrist, the prevalence may be higher.

The UN enters Guyon's tunnel after giving rise to dorsal cutaneous and palmar cutaneous branches. These two sensory branches to the hand do not enter Guyon's tunnel. The UN is apposed to the ulnar artery as it travels adjacent to the pisiform. The UN bifurcates into the superficial sensory branch and the deep motor branch distal to the pisiform but proximal to the hook of the hamate. The superficial sensory branch innervates the palmaris brevis muscle and is the sensory branch for the ulnar surface of the hypothenar eminence and the ulnar half of the fourth and fifth digits. The superficial branch further bifurcates into digital nerves distal to the hamate hook to innervate the fourth and fifth fingers [5]. The deep motor branch supplies the hypothenar muscles, including the abductor and flexor digiti minimi. It then rotates about the hook of the hamate and deviates laterally across the palm to innervate the dorsal interossei, the third and fourth lumbricals, the adductor pollicis, the flexor pollicis brevis, and terminates in the first dorsal interosseous muscle [5,6].

Ultrasonography has been increasingly used to assess the peripheral nervous system (PNS) both morphologically and dynamically [7–11]. Morphological assessment of the PNS typically involves measurements of the nerve cross-sectional area (CSA) [7,9,10,12–15]. Many reports have demonstrated correlations between enlarged nerve CSA and neuropathy, which have been documented both clinically and electrophysiologically [9,12,16–22]. In addition, enlarged CSA has been shown to correlate with clinical severity in patients with ulnar and median neuropathies [11]. There is a lack of sonographic diagnostic criteria for UN entrapment in Guyon's tunnel. Gross and Gelberman [5] described the internal topography of Guyon's tunnel to simplify localization of lesions. Zone 1 corresponds to the entrance of the tunnel through to the bifurcation of the UN. Zone 2 is distal and medial from Zone 1 and contains the motor branch. Zone 3 is radial to Zone 2 and distal to Zone 1, and contains the superficial sensory branch. Recently, there was a reclassification based on clinicoanatomic presentation to include two additional zones, however, it should be noted that Zones 1–3 were largely unchanged [8].

The purpose of this study was to measure the CSA of the UN in Zones 1, 2, and 3 of Guyon's tunnel and to test for correlations between the UN CSA and anthropometric measurements of the hand. In addition, we describe the presence and nature of the associated vascular structures within the tunnel of Guyon as evaluated using power Doppler imaging.

Materials and methods

The study protocol was approved by the Institutional Review Board and informed written consent was obtained. Asymptomatic volunteers between the ages of 18 years and 65 years were recruited through a convenience sample of university students, staff, and faculty. Volunteers completed a questionnaire documenting general health, handedness, specific health conditions (peripheral neuropathy or demyelinating diseases, stroke, diabetes, malnutrition, hypothyroidism, rheumatoid arthritis and other rheumatoid or connective tissue diseases, osteoarthritis, or pregnancy), work and sport history, and present or past hand/wrist injury status. Exclusion criteria included any upper extremity symptoms within the past 6 months, previous or present hand or wrist injury or surgery, specific health conditions such as peripheral neuropathy, demyelinating disease, stroke, diabetes, malnutrition, hypothyroidism, rheumatoid arthritis, connective tissue disease, pregnancy, and severe cardiovascular and/or respiratory diseases. Ultrasound measures and anthropometric data were collected, on one or both wrists, from 46 volunteers (16 female; mean age 24.7 $\pm$ 3.1 years) for a total of 83 wrists. Nine wrists were excluded (4 due to prior fracture and/or surgery, 2 due to prior sprain without surgery, and 3 due to recent paresthesia within the UN distribution in the hand). There were 41 dominant wrists and 42 nondominant wrists.

Anthropometric measurements of the wrist and hand were obtained using digital calipers (UltraTech, General Tools and Instruments, New York, NY, USA) and measuring tape by an examiner blinded to the ultrasound nerve CSA measurements. The anthropometric measurements (Figure 1) included wrist width (distance between the outer borders of radial and ulnar styloid processes), wrist depth (volar to dorsal distance at distal wrist crease), wrist circumference (at distal wrist crease), hand width (distance between second and fifth metacarpal heads), and palm length (middle point of distal wrist crease to middle point of third metacarpophalangeal joint).

Gray-scale sonography examinations were performed using an L8-18i transducer (GE LOGIQ E9 sonographic system; GE Healthcare, Milwaukee, WI, USA) by a board-certified chiropractic radiologist with 3 years' experience in musculoskeletal sonography. All scans were performed on the volar aspect of the wrist with the volunteer seated and their forearm/wrist resting comfortably in full supination on an examination table. The flexor carpi ulnaris tendon was identified at the volar wrist crease as an initial external reference point. The bony acoustical landmarks of the pisiform and the hook of the hamate were used as internal reference points during scanning. A liberal amount of coupling gel was applied to the volar hand and wrist. Cine