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● *Original Contribution*

ASSESSING THE RELIABILITY OF ULTRASOUND IMAGING TO EXAMINE RADIAL NERVE EXCURSION

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Abstract—Ultrasound imaging allows cost effective *in vivo* analysis for quantifying peripheral nerve excursion. This study used ultrasound imaging to quantify longitudinal radial nerve excursion during various active and passive wrist movements in healthy participants. Frame-by-frame cross-correlation software allowed calculation of nerve excursion from video sequences. The reliability of ultrasound measurement of longitudinal radial nerve excursion was moderate to high (intraclass correlation coefficient range = 0.63–0.86, standard error of measurement 0.19–0.48). Radial nerve excursion ranged from 0.41 to 4.03 mm induced by wrist flexion and 0.28 to 2.91 mm induced by wrist ulnar deviation. No significant difference was seen in radial nerve excursion during either wrist movement ($p > 0.05$). Wrist movements performed in forearm supination produced larger overall nerve excursion (1.41 ± 0.32 mm) compared with those performed in forearm pronation (1.06 ± 0.31 mm) ($p < 0.01$). Real-time ultrasound is a reliable, cost-effective, *in vivo* method for analysis of radial nerve excursion. (E-mail: richard.ellis@aut.ac.nz)

Key Words: **Ultrasound imaging, Radial nerve, Nerve mobilisation, Reliability.**

INTRODUCTION

Compressive peripheral neuropathies are a common cause of musculoskeletal disorders of the upper limb. The most common peripheral neuropathy is carpal tunnel syndrome (CTS), which has a lifetime risk of approximately 10% (Winterton and Farnell 2013). There is compelling evidence that impaired median nerve excursion (or movement) is an important aetiological factor for CTS (Filius et al. 2013; Hough et al. 2007; Liong et al. 2014). However, links between peripheral neuropathies of the forearm and impaired nerve excursion have yet to be established.

It has been hypothesised that impaired peripheral nerve excursion may also be a factor in other peripheral neuropathies. For example, compression of the radial nerve with associated movement impairment has been implicated in several clinical conditions such as radial tunnel syndrome (Cleary 2006), posterior interosseous nerve entrapment (Djurdjevic et al. 2014) and superficial radial nerve compression (Dang and Rodner 2009). The epidemiology for radial nerve compressive neuropathies is uncertain.

It has been suggested that reduced nerve excursion alters nerve function by increasing the neural tension, which may adversely contribute to pain (Dilley et al. 2008; Erel et al. 2003). Therefore, a method to allow quantification of nerve excursion would be of value, particularly for those conditions where nerve excursion is believed to be impaired.

In recent times the resolution and imaging capabilities of diagnostic ultrasound technology has greatly improved (Bianchi 2008). The unique ability of ultrasound imaging (USI) to provide an accurate and cost effective assessment of nerve movement, both real-time and *in vivo,* has made it a viable and effective tool for imaging in clinical practice (Bianchi 2008; Heinemeyer and Reimers 1999). USI is the preferred method for evaluating peripheral nerve morphology and motion (Tagliafico and Martinoli 2013) and has been shown to assist in the diagnosis of compressive neuropathies (Bargalló et al. 2010; Wiesler et al. 2006). For example,

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the use of USI to quantify median nerve excursion has become an integral part of the diagnostic screening for CTS (McDonagh et al. 2015; Uchiyama et al. 2010). The value of USI to assess radial nerve excursion, from a clinical perspective, is yet to be established. The assessment of nerve mechanics using USI offers potential advantages over other forms of static imaging techniques in that it allows a more dynamic and functional clinical assessment for compressive neuropathies.

Several studies have shown USI to reliably quantify excursion for the median (Coppieters et al. 2009), ulnar (Dilley et al. 2007), sciatic (Ellis et al. 2008; Ellis et al. 2012) and tibial nerves (Carroll et al. 2012; Ellis et al. 2008). To date, the majority of research has investigated the median nerve due to its association in common neuropathies (*e.g.,* CTS) and ease of location (Coppieters et al. 2009; Dilley et al. 2003). Although there have been reports of cadaver research to examine radial nerve excursion (Wright et al. 2005), there is a lack of *in vivo* research investigating excursion of the radial nerve.

USI has been advocated for the diagnostic assessment of CTS (McDonagh et al. 2015; Uchiyama et al. 2010). It is possible that the assessment of radial nerve excursion may also become an important diagnostic tool for conditions where radial nerve dysfunction is perceived. It is important to determine the reliability of USI to examine radial nerve excursion and to establish normative data for radial nerve excursion in healthy populations before its use in clinical populations can be fully realised. Therefore, there were two objectives of the present study. The first was to determine the test-retest reliability of measuring radial nerve excursion. It was hypothesised that the reliability of assessing radial nerve excursion with USI would show similar high levels of reliability as has been seen for other peripheral nerves (*e.g.,* median, sciatic, tibial, *etc.*). The second objective of this study was to quantify the extent of radial nerve excursion for different combinations of movement at the forearm and wrist using USI.

MATERIALS AND METHODS

Study design

A controlled laboratory cross-sectional study using a single-group, within-participant comparison was utilised for this research.

Participants

Thirty participants were recruited for this study from a population of convenience. Recruitment of participants was conducted through the use of advertisements placed on university student noticeboards and social media sites. Participants were included if they were healthy individuals aged 18–50 y. Participants were excluded if they had a history of significant/major trauma or surgery to the spine, shoulder, elbow or wrist regions; symptoms consistent with radial nerve impairment (*e.g.,* paraesthesia, weakness, *etc.*); or a known history of a neurologic disorder or known conditions that may negatively affect the nervous system (such as diabetes mellitus). Informed consent was obtained from all participants before testing. Ethics approval was provided by the Auckland University of Technology Ethics Committee.

Equipment and procedures

Participant set-up. Participants were positioned in supine with their arm supported by a table adjacent to the plinth with the shoulder in 45° abduction and the elbow held in full extension. The wrist was unsupported, over the edge of the table, to allow full movement at the wrist. Shoulder and elbow position were reassessed between each test condition to ensure no movement of the shoulder and elbow joint had occurred during the testing procedure.

Movements of the wrist were used to induce movement of the radial nerve. Two different forearm positions were used for all of the wrist movements: forearm supination and pronation. These two positions have been suggested to expose the radial nerve to different levels of strain (Nee et al. 2012; Wright et al. 2005), which may, in turn, influence radial nerve excursion. The order of forearm positions (pronation or supination) adopted during testing was determined using a random number generator. In all participants, the right arm was imaged.

Wrist movements performed. Several movements of the wrist were utilised to induce excursion of the radial nerve. All wrist movements were performed both actively (by the participant) and passively (by the research assistant) within the participant's maximum tolerable range of motion (ROM). Using a participant's tolerable ROM has previously been shown to produce reliable results when assessing peripheral nerve excursion (Ellis et al. 2015). Wrist ROM was recorded with an electrogoniometer (Penny and Giles, Newport, UK). The electrogoniometer was calibrated against a manual goniometer before each testing session at 0° and 45° wrist extension or ulnar deviation (depending on the condition). The use of each participant's maximal tolerable ROM was selected because it offered the potential for greater nerve excursion compared to standardising ROM, as previously shown for assessment of the sciatic nerve (Ellis et al. 2015). All movements were performed in a thermoplastic splint that held the metacarpophalangeal joints in a standardised position of 30° of flexion but allowed free wrist