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Improving the radial nerve neurodynamic test: An observation of tension of the radial, median and ulnar nerves during upper limb positioning

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ABSTRACT

The radial nerve neurodynamic test (ULNT2b), used to implicate symptoms arising from the radial nerve, is proposed to selectively increase strain of the nerve without increasing strain of adjacent tissue, though this has not been established. This study aimed to determine the upper limb position that results in: (1) the greatest tension of the radial nerve and (2) the greatest difference in tension between the radial nerve and the other two major nerves of the upper limb: median and ulnar. Tension (N) of the radial, median and ulnar nerves was measured simultaneously using three buckle force transducers during seven upper limb positions in the axilla of ten embalmed whole body human cadavers (n = 20 limbs). Repeated measures analysis of variance (ANOVA) with Bonferroni post-hoc tests determined differences in tension between nerves and between limb positions. A Composite position consisting of ULNT2b (scapular depression, shoulder internal rotation, elbow extension, forearm pronation, wrist flexion) with the addition of shoulder abduction 40° and extension 25°, wrist ulnar deviation and thumb flexion demonstrated significantly greater tension of the radial nerve than any other tested position (mean tension 11.32N; 95% CI 10.25, 12.29, $p < 0.01$), including ULNT2b (2.20N; 1.84, 2.57; $p < 0.01$). Additionally, the Composite position demonstrated the greatest difference in tension between the radial and median (mean difference 4.88N; 95% CI 3.16, 6.61; $p < 0.01$) and radial and ulnar nerves (9.26N, 7.54, 10.99; $p < 0.01$). This position constitutes a biomechanically plausible test to detect neuropathic pain related to the radial nerve.

1. Introduction

The radial, median and ulnar nerve upper limb neurodynamic tests (ULNTs) are designed to assess the interplay between mechanics and physiology of the three major nerves of the arm (Shacklock, 1995). The radial nerve bias ULNT (ULNT2b) is purported to examine the radial nerve, along with its connections to the brachial plexus and nerve roots, to determine its contribution to neuropathic symptoms of the upper limb or neck (Keneally et al., 1988; Butler, 1991). The ability of ULNT2b to selectively increase tension of the radial nerve and surrounding tissue provides a foundation for its plausibility to detect neuropathic pain. (Elvey, 1979; Keneally et al., 1988; Selvaratnam et al., 1988). It is generally accepted that this mechanical provocation may be responsible for reproduction of the patient's symptoms (Walsh, 2005; Topp and Boyd, 2006). To confirm the diagnosis of neuropathic pain related to the radial nerve ULNT2b should reproduce symptoms in the sensory distribution of the radial nerve and the application of a sensitising maneuverer should change these symptoms (Butler, 2000). However, there is evidence from one previous human cadaveric study that ULNT2b may not selectively increase tension of the radial nerve (Kleinrensink et al., 2000). Furthermore, evidence suggests its application fails to selectively reproduce symptoms in the distribution of the radial nerve in symptomatic patients (Yaxley and Jull, 1993; Grant et al., 1995; Petersen et al., 2009). Therefore, clinical interpretation of ULNT2b may be inaccurate, leading to misdiagnoses and ineffective patient management.

The movements that comprise ULNT2b are based on the anatomical course of the radial nerve with respect to the joint axes of the upper limb (Breig, 1960, 1978; Sunderland, 1978, 1991). The movements that comprise the base ULNT2b include: scapular depression, elbow extension, shoulder internal rotation, forearm

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pronation and wrist flexion (Butler, 2000). Removal of scapular depression is thought to selectively decrease tension of the radial nerve with an associated decrease in symptoms, confirming the diagnosis of neuropathic pain related to the radial nerve (Butler, 2000). However, there is minimal quantitative research validating whether changes in radial nerve tension occur with changes in scapular depression. In fact, the application of scapular depression in isolation has been shown to have minimal effect on tension of the brachial plexus (Reid, 1987; Ginn, 1988), peripheral nerves (Lewis et al., 1998), or symptom reproduction (Yaxley and Jull, 1991). If scapular depression does not selectively increase tension of the radial nerve its application may compromise the validity of ULNT2b by evoking symptoms from adjacent musculoskeletal tissue (Wilson et al., 1994; Balster and Jull, 1997).

From anatomical (Tubbs et al., 2009; Chaudhry et al., 2010), and clinical (Butler, 2000) observations it has been proposed that the addition of shoulder abduction, shoulder extension, wrist ulnar deviation or thumb flexion to ULNT2b may selectively increase tension of the radial nerve. Clinically, these movements are referred to as sensitising maneuverers. Supporting this, Wright et al. (2005), demonstrated in five fresh frozen transthoracic cadaveric specimens that the movements comprising the base ULNT2b, as well as 110° shoulder abduction and 30° wrist ulnar deviation, when applied in isolation increased tension of the radial nerve. However, this study did not measure the tension of the other two major nerves of the upper limb. Therefore, conclusions cannot be drawn regarding the ability of these movements to selectively increase tension of the radial nerve.

The purpose of this study was to determine the upper limb position that results in: (1) the greatest tension of the radial nerve and (2) the greatest difference in tension between the radial nerve and the other two major nerves of the upper limb: median and ulnar. This position will constitute a biomechanically plausible upper limb neurodynamic test for the radial nerve based on the development of tensile force within the nervous system. As such it may contribute to more accurate clinical interpretation of symptom reproduction during testing, potentially improving the detection of neuropathic pain related to the radial nerve.

2. Method

2.1. Sample

Data were collected from ten whole-body embalmed human cadavers (mean age at death 81 years, range 65–94). All test procedures were applied to both upper limbs ($n = 20$ limbs). Whole cadavers were used to preserve the entire nervous system. All cadavers were embalmed using Arterial Anatomical NF (Genelyn Pty. Ltd., Australia) embalming fluid less than 48 h after death. Embalmed cadavers minimised biological risks, as used in previous studies (Coppieters et al., 2006; Coppieters and Alshami, 2007; Coppieters and Butler, 2008). Though embalmed cadavers demonstrate greater nerve tension than unembalmed ones, Kleinrensink et al. (1995) demonstrated a strong positive correlation in tension data between embalmed and unembalmed specimens. This implies the relative differences in tension on a nerve placed in varying positions are similar regardless of embalming, suggesting the use of embalmed specimens would provide acceptable data for comparing tension of the upper limb nerves. Cadavers donated to The University of Newcastle Body Donor Program between June 2008 and June 2011 were considered for entry into the study. Cadavers were excluded if they had upper limb pathology or inadequate joint range of motion (ROM) preventing neurodynamic testing using usual clinical methods (specified joint ranges for exclusion listed in Table 1). Five of 15 cadavers were excluded due to inadequate joint ROM. Institutional ethics approval was obtained. Data from these cadavers have also been used to produce a separate manuscript regarding ulnar nerve neurodynamic testing.

Table 1
Joint range of motion (ROM) exclusion criteria for cadavers for neurodynamic testing. Cadavers were excluded if inadequate ROM prevented testing using usual clinical methods.

Joint	Movement	Range of Motion
Shoulder	Abduction	$<40°$
	Extension	$<25°$
	Internal rotation	$<60°$
Elbow	Extension	$<0°$
Wrist	Flexion	$<65°$
	Ulnar deviation	$<10°$
Thumb	Flexion	$<25°$

2.2. Data collection

The present study defined tension as the longitudinal force applied to a nerve in response to movement of the upper limb (Rodgers and Cavanagh, 1984). Blunt dissection was undertaken for the placement of instrumentation to measure tension. A shallow incision measuring 10 × 5 cm was made in the axilla to expose the radial, median and ulnar nerves. Minimal dissection (only the skin and subcutaneous tissue overlying each nerve necessary for accurate tension recordings) preserved the relationship between the nerves and surrounding tissue. This limited disruption of the nerve bed and neural mechanics.

A buckle force transducer (BFT) measured tension. This device has demonstrated reliability when measuring tension in non-biological tissue (Ginn et al., 1993) and in the three major nerves of the upper limb in embalmed human cadavers (Kleinrensink et al., 2000). The BFT consisted of a stainless steel rectangular frame, a central bridge and a strain gauge (Applied Measurement, Australia). The nerve to be tested was threaded through the buckle (Fig. 1), such that an increase in nerve tension applied a force to the bridge, which produced a bending moment on the frame. This was detected by the strain gauge (mV), which formed one limb of a Wheatstone bridge circuit. The output from the strain gauge was displayed in mV in Labview Version 10.0 (National Instruments, Australia), and then converted to Newtons for analysis.

Single BFTs were simultaneously attached to the radial, ulnar and median nerves at standardised sites 2, 5 and 8 cm distal to the

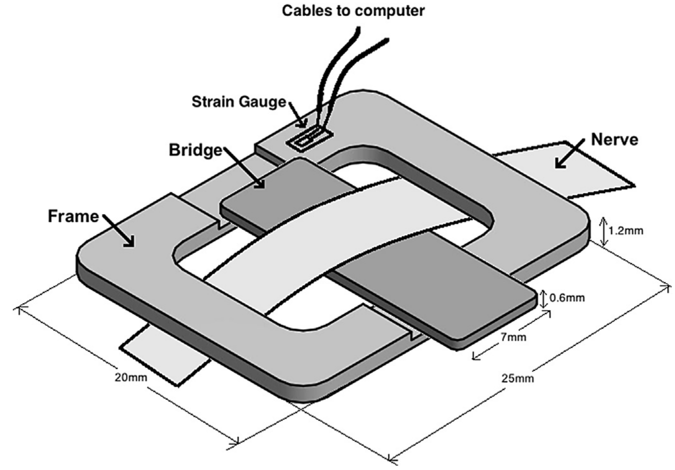

Fig. 1. Schematic buckle force transducer with a nerve segment.