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Scientific/Clinical Article

Is there a relationship between impaired median nerve excursion and carpal tunnel syndrome? A systematic review

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ABSTRACT

Study Design: Systematic review.
Introduction: It is accepted that the etiology of carpal tunnel syndrome (CTS) is multifactorial. One of the most commonly accepted etiologic factors for CTS is compromise of the kinematic behavior and excursion of the median nerve.
Purpose of the Study: The objective of this systematic review was to establish if there is a relationship between impaired median nerve excursion and CTS.
Methods: A systematic review, following the Preferred Reporting Items for Systematic Reviews and Meta-analyses guidelines, was conducted. Studies were sought where in vivo median nerve excursion was compared between people with CTS to an appropriate control group. Quality appraisal for each study was conducted using the Newcastle-Ottawa Scale by 2 independent evaluators.
Results: Ten case-control studies using ultrasound imaging to quantify median nerve excursion were included. All studies were rated as of "moderate" methodologic quality having scored 6 or 7 (of 9 stars) for the Newcastle-Ottawa Scale. Seven of the 10 studies concluded that median nerve excursion was reduced in a CTS population when compared with controls.
Conclusion: The literature suggests that median nerve excursion is reduced in people with CTS when compared with healthy controls.
Level of Evidence: 3a.

Introduction

Carpal tunnel syndrome (CTS) is the most commonly reported peripheral neuropathy,[1-4] with a prevalence of approximately 3%-4% in the general population.[2,5] Although the precise etiology of CTS remains unclear,[3,4] it is most likely multifactorial with many different theories postulated as to the exact mechanisms which contribute to common symptoms of numbness, pain, and tingling throughout the distribution of the median nerve.[2,5-7]

In response to postures and movements of daily living, the median nerve (along with the entire peripheral nervous system) is constantly exposed to significant stresses which it must cope with and adapt to.[4] Such stresses can be applied in a myriad of ways that include compressive, tensile, shear stress, or a combination of these.[8] Peripheral nerve excursion, whether in transverse and/or longitudinal planes, is directly influenced by the adjacent joints that impose movement upon it.[9] Nerve movement in this regard is essential to dissipate such mechanical stresses.[8,10]

One of the most commonly accepted etiologic factors for CTS is the kinematic behavior and excursion of the median nerve which is compromised due to a number of different factors. One of these factors being a narrower carpal tunnel volume and an increase in pressure within the enclosed space.[6] This increase in intratunnel pressure is thought to cause compression of the median nerve causing subsequent venous congestion and edema together with an invasion of fibroblasts to the affected tissues which may then lead to the formation of restrictive scar tissue.[5,6] Significant compression of the median nerve may alter the normal sliding and gliding kinematics, as discussed previously.[11] The section of nerve proximal

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to the compression can also become enlarged secondary to increased endoneurial connective tissue, edema, or an obstruction of axoplasmic flow.[5] A number of studies have shown that the cross-sectional area (CSA) of the median nerve is increased in people with CTS compared with healthy controls, this is likely secondary to the factors previously discussed, which would contribute to increased pressure and compression of the median nerve.[12,13] It is also thought that swelling of the flexor tendons and thickening of the subsynovial connective tissue (SSCT) may contribute to an increase in pressure within the carpal tunnel.[1,4]

In conjunction with thickening of the SSCT and the consequential increase in pressure, it is also apparent that the median nerve may become adhered to the SSCT[1,3,14] and or to the transverse ligament.[1,15] Adherence of the median nerve to surrounding tissues and structures may be a further reason for altered excursion of the median nerve in those suffering from CTS. If the median nerve is not free to slide, then segments of the nerve are forced to accommodate the required change in length which may create an increase in local strain.[11] As in CTS, it has been previously shown that an increase in nerve strain of as little as 6% can lead to altered nerve function.[11]

The diagnosis of CTS is primarily made using clinical findings such as Phalen's test, Tinel's sign, and sensory changes in the distribution of the median nerve.[16] Positive clinical findings are commonly confirmed through the use of nerve conduction studies (NCS).[16] The role of medical imaging (ie, ultrasound imaging [USI], magnetic resonance imaging, and so forth) for the diagnosis of CTS is gaining momentum. There is compelling evidence which indicates that the CSA of the median nerve (used as an indirect measure of intraneural edema) at the carpal tunnel inlet is significantly greater in people with CTS and is the most sensitive and specific USI finding for the diagnosis of CTS.[17] Research evidence also concludes that the use of USI as a diagnostic tool for CTS is approaching similar values of diagnostic accuracy to that of NCS[17] with sensitivity of 0.89 and specificity of 0.88 when comparing patients who have CTS confirmed through clinical examination and NCS as a reference standard.[18]

USI has been shown to be a reliable and accurate tool for establishing the excursion of the median nerve.[2] Although the evidence is in agreement about the effectiveness of USI to confirm CTS, there is variability in the reported normative values proposed for median nerve CSA and excursion. This variability may be due to differences in USI techniques reported and/or differences in disease severity and/or duration of those cohorts investigated.[5,17]

In vivo measurement of median nerve excursion can also be measured intraoperatively through insertion of a marker into the median nerve and fluoroscopic imaging during wrist movement.[19] This intraoperative method of imaging is a useful in vivo excursion measurement, although it has been noted that the measurement can only be assumed accurate at the time of surgery and that changes in excursion in relation to healing and scar tissue formation after the surgery are not accounted for.[19]

Purpose of the study

Currently, controversy surrounds whether reduced median nerve excursion is a relevant feature in CTS with some studies suggesting a reduction of median nerve excursion is evident while others suggest otherwise. In light of this controversy,[11] a systematic review of literature is required to examine those studies that have assessed the relevance of median nerve excursion in people with CTS. There is a need to develop a greater understanding about the altered dynamics of the median nerve in CTS and if reduced excursion of the median nerve has a direct relationship with a diagnosis of CTS. The objective of this systematic review was to explore the current literature and establish if a relationship exists between impaired median nerve excursion and CTS.

Methods

Although the protocol for this systematic review has not been registered, this manuscript has been written and formatted in accordance to the Preferred Reporting Items for Systematic Reviews and Meta-analyses statement.[20]

Information sources and search

An extensive literature search was carried out across a number of different databases to identify literature relevant to median nerve excursion in people with CTS. The databases searched electronically were EBSCO Health, Scopus, MEDline, CINAHL, ProQuest Nursing, Scopus, and Allied Health Source. The keywords that formed the basis of the search (Table 1) were "median nerve excursion," "median nerve movement," "median nerve sliding," "median nerve gliding," "carpal tunnel syndrome," "median nerve entrapment and carpal tunnel." These keywords were expanded through the use of truncation, synonym searching, and proximity searches. Studies found using this search strategy were reviewed using their title and abstracts and the studies meeting inclusion criteria were selected. The search was completed by March 1, 2016, and there was no restriction placed on publication date.

Eligibility criteria

Studies were selected if they met the following inclusion criteria:

- CTS was the primary condition of interest. Each study must have included participants with a diagnosis of CTS which was made either by (1) applying a rigorous diagnostic criteria for CTS (ie, Quality Standards Subcommittee of the American Academy of Neurology and so forth) or (2) following documented clinical assessment (eg, electrodiagnostic testing [ie, NCS], medical imaging, and so forth);
- Use of an assessment tool (ie, medical imaging, surgical visualization, and so forth) which allowed direct, real-time, in vivo measurement of median nerve excursion;
- Comparative study designs (ie, case-control studies, cohort studies, and so forth) comparing a cohort of people with CTS to an appropriate cohort of healthy controls;

Table 1
Study characteristics

Study	Study design	CTS group (n)	Control group (n)	In vivo tool
Erel et al[11]	Case-control	17	19	USI
Filius et al[14]	Case-control	25	14	USI
Hough et al[2]	Case-control	19	37	USI
Kuo et al[6]	Case-control	25	19	USI
Kuo et al[7]	Case-control	40	32	USI
Liong et al[12]	Case-control	12	15	USI
Nakamichi and Tachibana[15]	Case-control	30	30	USI
van Doesburg et al[28]	Case-control	29	29	USI
Wang et al[4]	Case-control	20	20	USI
Yoshii et al[16]	Case-control	51	62	USI

n = participant numbers; USI = ultrasound imaging.