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Supporting occupational health and wellbeing professionals

Carpal tunnel syndrome and work with hand-held vibrating tools

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1. INTRODUCTION

1. The following summary of CTS and work with hand-held vibratory tools has been produced by members of The Society of Occupational Medicine HAVS Special Interest Group (SIG) as a resource to assist those involved in the diagnosis and management of workers with carpal tunnel syndrome or thought to be at risk of developing CTS because of using hand-held vibratory tools.
2. This guide does not aim to be a comprehensive overview of CTS and vibratory tool use, nor does it seek to replace existing guidelines or formal education. Rather, it is a practical summary intended to provide background information and assist the practitioners undertaking surveillance of those using hand-held vibratory tools.
3. The guide has been prepared by members of a working group set up by The Society of Occupational Medicine (SOM), but each section does not necessarily represent the views of any individual member of the group, and the working group makes no assumption that its recommendations represent the views of all the members of the SOM.
4. While the guide is presented in good faith, it is the responsibility of the reader to ensure that their approach to matters relating to HAVS and CTS accords with best current practice, and legal requirements, and the SOM will accept no responsibility resulting from the failure of any reader to ensure that they do so.
5. The Special Interest Group welcomes any comments or suggestions regarding this publication. The SOM will assist members by directing specific enquiries about HAVS or CTS to an appropriate member of the Group.
6. The Society of Occupational Medicine would like to thank **Dr Roger Cooke** and **Dr Ian Lawson** who gave their time and expertise in developing this guide, and members of the SOM HAVS Special Interest Group for support, comments, and suggestions.
7. Occupational health practitioners assessing vibration related hand conditions play a pivotal role in the identification of HAVS and carpal tunnel syndrome (CTS) in workers using handheld vibratory tools. They will also be involved in advising employees and employers when there is a need to reduce exposure to vibration to limit the progression of disease. The correct diagnosis and subsequent management of vibration related symptoms can be challenging to the health practitioner who sees only occasional cases of HAVS or CTS, given the complexity of the medical and employment issues.
8. According to modern practice standards, clinical activity is expected to be reliable and based on the current best evidence. In medicine this is usually based on peer-reviewed, published scientific literature. Evidence based medicine provides a framework for clinical decision-making processes and integrates the evidence with clinical experience and individualized subject factors. However, the evidence may be limited in its relevance and applicability, as is often the case in CTS.
9. The aim of this document is to provide general advice on CTS and combine a review of the best available evidence for management with current expert practice. Accordingly, the document aims to summarise the substantial amount of evidence currently available for the management of HAVS in a concise and easily readable form. It provides consensus views of the group in respect of best practice, some key evidence and includes useful tips and advice to avoid common pitfalls.
10. The document has been developed primarily for occupational health practitioners who are engaged with managing and supporting workers with CTS. It may also be accessed by other health professionals or technicians who may find the content useful. The intention is not to provide prescriptive rules for individual cases but to assist with diagnosis and management of CTS in the workplace.

2. KEY MESSAGES

1. *A low threshold of suspicion of CTS is recommended in all cases of paraesthesiae in the hands or digits.*

2. *While it is possible for CTS and HAVS to co-exist, HAVS should normally be regarded as a diagnosis of exclusion.*

3. *Before confirming a diagnosis of dual pathology, a full assessment should be undertaken followed by treatment of the CTS if indicated.*

4. *It is not possible to grade any suspected co-morbid sensorineural HAVS until CTS, if present, is adequately treated.*

5. *In some cases, diagnosis of CTS may be made clinically.*

6. *Nerve conduction studies may assist in the diagnosis but have a significant false negative rate, typically about 25% (see section 5 below). Multisegmental tests may have additional value.*

7. *Occupational health advice may include appropriate use of carpal tunnel splints while awaiting further investigation or assessment, along with undertaking an ergonomic risk assessment of vibrating tool usage to ensure legal limits observed and holding techniques optimized.*

8. *A significant symptomatic improvement following steroid injection into the carpal tunnel in vibration exposed is a useful surrogate confirmation of entrapment neuropathy as opposed to sensorineural HAVS.*

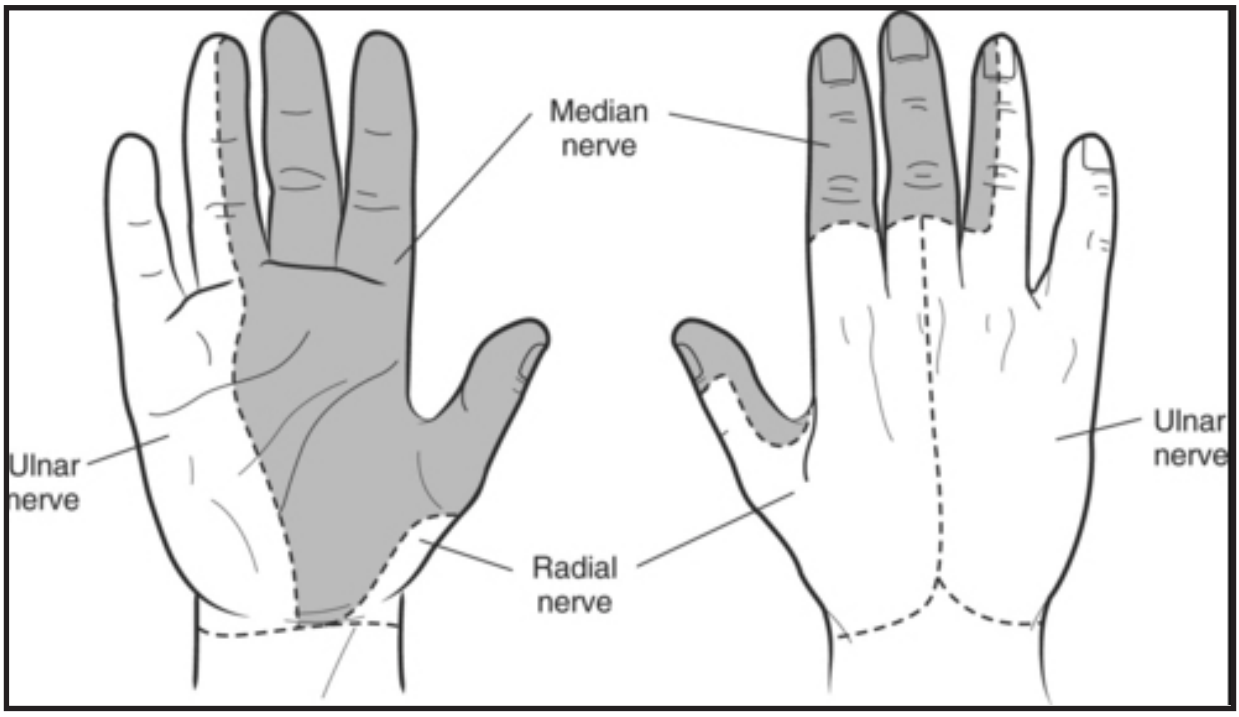
3. BACKGROUND

Carpal Tunnel Syndrome (CTS) is generally accepted as being the commonest peripheral nerve entrapment syndrome, with a 10% lifetime risk of the condition and reported to affect 7-16% of the adult population idiopathically, being more common in females and with increasing prevalence with age, particularly between the ages of 45 and 64 years. [i]

4. PRESENTATION

The median nerve entrapment occurs as it passes through the carpal tunnel on the palmar aspect of the wrist. Classical sensory symptoms of CTS reflect the sensory distribution of that nerve, being the thumb, index and middle fingers and the lateral aspect of the ring finger. The lateral side of the palm of the hand is supplied by the palmar branch of the median nerve arising from the median nerve a few centimeters above the wrist and does not go through the carpal tunnel and therefore one might expect that the palm is not affected in the CTS. However, involvement of the palm is well recognised, and full 'glove' distribution of symptoms has been found in 35% of cases of CTS. Nora et al[ii] found that among patients with neurophysiological CTS, 44.4% had palmar pain and 62.2% had palmar paraesthesiae. Similarly, Clark et al found 39% prevalence of symptoms affecting the little finger in CTS diagnosed by hand diagrams, neurophysiology, and monofilaments.[iii]

CTS also has motor symptoms, reflecting the median innervation of the first and second lumbrical muscles and those of the thenar eminence. That may be manifest by wasting of the thenar eminence and weakness of thumb opposition.



5. DIAGNOSIS

The diagnosis of CTS may be undertaken clinically, and there are several validated methods for doing so. The Primary Care Rheumatology Society Criteria and the six question CTS diagnosis (CTS-6) – see tables at Appendix 1 & 2. The Industrial Injuries Benefits Handbook 2 notes that 'nerve conduction studies are not essential if the diagnosis (of CTS) can be made on the basis of history and clinical findings'.

Nerve conduction studies (NCS) are sometimes referred to as the "gold standard" for diagnosis of CTS, and there is a view that being objective tests – i.e. without being reliant on patient input or feedback – nerve conduction studies (NCS) would be 100% reliable for the diagnosis of CTS. However, it is also generally accepted that they are not infallible. The term 'sensitivity' is used to define the ability of a test to correctly identify those with the relevant condition. There are several studies reporting this issue of false positive and false negative results in respect of nerve conduction studies. False negative results of NCS in reported studies range from 8% to 51%, with several indicating false negatives in the range 18-25%. This suggests that about 1 in 4 to 1 in 5 negative tests fail to diagnose CTS. By way of example, when using a selection of parameters (i.e. not just nerve conduction velocity) the sensitivity of nerve conduction studies has been reported as 75%[iv], and studies considering clinical diagnosis with symptom relief after surgery as the diagnostic standard found NCS sensitivities of 74% and 78%[v]. Based on these studies, NCS are expected to positively identify, or confirm, only about 75% of those with CTS. The specificity (ability to detect those without CTS) of NCS is significantly higher. The National Institute for Clinical Excellence (NICE - 2016) recommend further assessment where the diagnosis is unclear, or a serious alternative diagnosis is suspected.

In a systematic review Dabbagh et al looked at clinical diagnostic sensory and motor tests against four categories from the American Association of Orthopedic Surgeons (AAOS) Guidelines on the diagnosis and management of CTS:

1. Provocative manoeuvres (e.g. Durkan's test, Phalen's test).
2. Sensory and motor tests (e.g. heat/cold sensation, thenar muscle atrophy).
3. Questionnaires and scales - Boston carpal tunnel questionnaire, CTS-6 scale.
4. Hand symptoms diagrams (e.g. Katz and Stirrat's hand symptom diagrams).

The review found the most sensitive test for CTS diagnosis in the clinical setting was the Semmes Weinstein monofilament test, (3.22 monofilament size equivalent to the blue 0.2g-f of the WEST monofilament kit as normal threshold) in any radial finger (Sn values 49% to 96%) and potentially useful as a screening tool and examination. This is likely to be particularly relevant where examination of sensation in the little finger reveals no reduction of sensitivity.

6. PATHOLOGY

It is generally accepted that increased pressure within the carpal tunnel produces dysfunction of the median nerve as it passes through the tunnel, which may be evidenced by median nerve ischemia and demyelination. Pathological processes underlying that increased pressure are unclear. The tunnel itself contains a mixture of intrasynovial and subsynovial connective tissue (SSCT) and thickening of the SSCT is a characteristic finding in CTS, although it is not clear whether that is a consequence or a causative factor. It has been suggested that repetitive movement of tendons within the tunnel may produce shear injury to the SSCT, and consequent fibrosis. Dahlin has suggested that a low myelinated nerve fibre density may be a factor in the manifestation of symptoms associated of nerve entrapment in vibration-exposed[vii].

7. CAUSES OF CTS

Constitutional risk factors include diabetes[viii] and a high body mass index (BMI), as well as parity of 3 or more, osteoarthritis of the wrist, rheumatoid disease, and cigarette smoking. Hand and wrist shape may be important, with CTS reported as being more common in those with short wide 'square' hands[ix].

Occupational risk factors include forceful gripping (esp. over 1kgm force), repetitive flexion and extension at the wrist, high force- high repetition work and use of a precision type of hand grip.

CTS arising from work with hand-held vibrating tools is a prescribed disease and reportable under the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 2013.

Prescription for PD A12(a) requires '...the use at the time the symptoms first develop, of hand-held powered tools....' Therefore, the onset of symptoms must post-date the start of work with vibrating tools and exclude those developing after exposure has ceased.

The Industrial Injuries Advisory Council (IIAC) looks for consistent evidence of more than a doubling of relative risk (RR or OR) for common conditions in the general population before recommending addition to the list of prescribed diseases. In other words, is it 'more likely than not' that the condition will develop with exposure to hand-held vibrating tools?

Consistent and repeated epidemiological evidence including meta-analyses and systematic reviews have shown an association between use of vibratory tools and development of CTS. Odds ratios (OR) between >2 to 5.4 have been shown in studies with defined diagnostic criteria, control groups and potential confounders[x, xi, xii]. Systematic reviews have also shown strong to moderate associations (OR 2.5—4. 8) [xiii, xiv].

There is however a range of opinion regarding the role of vibration per se as distinct from the use of vibrating tools. There is no consensus for a dose-response model for vibration exposure and CTS, with insufficient data on exposure and inherent difficulties in assessing other potentially confounding factors, such as posture or grip. Gillibrand et al found no evidence that below the current limit for A(8) of 5 m/s2, higher exposures to HTV predispose to CTS [xv]. However, Lawson has noted that an absence of evidence does not necessarily mean there is no dose-response relationship - only those studies have so far failed to identify one [xvi]. Lawson went on to state that whilst each case should be treated individually, he was of the opinion that the epidemiological evidence is sufficiently robust (even in the presence of non-occupational risk factors such as a high BMI), for occupational physicians to assign causation of CTS from work with hand-held vibrating tools.

For reporting CTS under RIDDOR 2013, the occupational requirement is that '...the person's work involves regular use of percussive or vibrating tools'. The wording of regulation 8(a) does not require that the condition occur during a period of use of such tools or is caused by or made significantly worse by work.

HSE Guidance L140 (2019 - Appendix 8 Paragraph 6) states that cases of vibration induced CTS should be reported, but the wording of the RIDDOR legislation is such that employers are required to report any case of CTS occurring in individuals working regularly with percussive or vibrating tools, and the presence of other risk factors should not preclude reporting when these criteria are met. There is no definition of 'regular' within RIDDOR, and although the HSE Inspection and Enforcement Guidance 2020 refers to exposure being regular and frequent if it is repeated several days each week over months and years [xvii], it is unclear whether this definition can be applied to RIDDOR.

8. DIFFERENTIAL DIAGNOSIS

Cubital tunnel syndrome and Guyon tunnel syndrome

The ulnar nerve may be compressed either within the Guyon tunnel at the wrist, or the cubital tunnel at the elbow. Guyon tunnel syndrome may result from direct trauma, over the hypothenar area of the wrist/hand and presentations may include sensory disturbances in the little and ring fingers, clawing of the hand, atrophy of the hypothenar eminence and inability to cross fingers. Tinel's sign may be positive. 'Foetal' sleepers and those who swap hands when using a mobile phone because of sensory symptoms is suggestive of cubital tunnel syndrome. A fixed flexion test at the elbow if cubital tunnel is suspected (elbow flexion, wrist extension for one minute, positive if paresthesia in ulnar nerve distribution).

In cubital tunnel syndrome, numbness and tingling may occur over the ulnar aspect of the hand, and the little and ring fingers, being aggravated by postures such as when driving or holding a phone. There may be difficulty with fine finger movements. Nerve conduction studies are likely to assist in these diagnoses.

Pronator teres syndrome

The median nerve may also be trapped more proximally between the two heads of the pronator teres muscle, as pronator teres syndrome, which is estimated to account for ~9% of median nerve entrapments. In comparison with CTS, pronator teres syndrome is likely to be suggested by the absence of nocturnal exacerbation and aggravation of symptoms by repeated pronation and supination of the forearm. Distinction between pronator teres syndrome and CTS may require nerve conduction studies.

Cervical radiculopathy

Cervical spondylosis is a common condition in the general population and may be associated with nerve root compression or irritation. The 6th, 7th and 8th cervical nerve roots provide sensory innervation of the hands, with the 6th and 7th cervical dermatomes being like the area innervated by the median nerve. Other features such as a history of neck trauma, neck pain or stiffness, shooting or burning pain down the arms, and exacerbation of symptoms by neck movement may help identify cervical radiculopathy.

Double crush

The phenomenon of 'double crush' is recognised, being that irritation of a nerve trunk at one level means that irritation at a second level is more commonly seen. In the original paper describing this, Upton and McComas further suggested that a high proportion (75%) of patients with one peripheral nerve lesion did in fact have a second lesion elsewhere and they implied that both lesions were contributing to the symptoms [xviii, xix]. The common manifestation of this is cervical nerve root lesions being associated with carpal tunnel syndrome. It is known that proximal nerve root compression – as in cervical spondylosis – means that less involvement of the carpal tunnel is required to produce symptoms. It is possible that prolonged cervical nerve root irritation could be a significant factor in development of CTS due to double crush. Some authors have suggested that treatment of the neck lesion is more important than treatment of the CTS, which may not respond to treatment until the neck problem has been resolved [xx].

Sensorineural hand arm vibration syndrome

The sensory symptoms presenting in CTS can be confused with sensory HAVS[xxi]. The neurological damage in sensorineural HAVS occurs in the fingertips, either the nerve endings of smaller diameter nerve fibres or mechanoreceptors. Therefore, the symptoms of tingling and numbness will be focused on the fingertips whereas in CTS the neurological damage occurs at the level of the wrist. Symptoms can affect the palm and entire length of the digits in CTS and may also extend proximally into the lower third of the forearm.

Differentiating between hand arm vibration syndrome (HAVS) and carpal tunnel syndrome (CTS) may be difficult, but the following features should be considered.

- Non-specific colour changes or colour changes affecting the palm or back of the hand are not features of HAVS but can occur in CTS.
- Cold intolerance without colour changes can occur in CTS, and there is limited evidence that it may be prodromal to vasospasm in HAVS.
- Pain is not a feature of sensorineural HAVS although pain may occur during the rewarm phase of Raynaud's phenomenon. Pain around the wrist or hand extending into the lower part of the forearm can occur in CTS.
- Nocturnal paraesthesiae or pain is characteristic of CTS. Similar reports in HAVS may be compounded by diagnostic uncertainty between the two conditions.
- Reduced manipulative dexterity can occur in CTS and HAVS.
- Raynaud's phenomenon can occur with either HAVS or CTS [xxii] . A 'median' distribution of colour change

may indicate CTS but could reflect specific grip and exposure to vibration of those digits as occurs with a 'tripod' workpiece grip using thumb, index, and middle fingers.

- Thenar atrophy may suggest CTS but does not occur in HAVS. Thenar atrophy is good at ruling in CTS, but poor at ruling it out [xxiii].
- Sensory changes over a typical distribution of the median nerve on examination (i.e. the thumb, index and middle fingers and associated area of the palm) is strongly suggestive of a diagnosis of CTS, although as noted already, the 'classical' distribution is not always found in CTS, and therefore is not essential to the diagnosis.
- Sensory changes in the little finger in CTS are relevant if the index finger is affected. Sensory changes sparing the little finger may however support a diagnosis of CTS. In this context a significant difference between monofilament result on the index and little fingers may support a CTS diagnosis in those with a supportive history. However, caution should be exercised in vibration exposed workers using a tripod grip.
- Examination findings of reduced sensation in the lower forearm can occur in CTS but not in HAVS.
- Loss of power grip strength may occur in either condition [xxiv].
- Reduction in pinch grip strength is a feature of CTS. (Neither power grip strength nor pinch strength has sufficient sensitivity or specificity to be used to diagnose musculoskeletal disorders in HAVS) [xxv].
- Phalen's, Tinel's and Gilliat's (pneumatic tourniquet) and other provocative tests support a diagnosis of CTS but not sensorineural HAVS. It is preferable to rely on a combination of the tests (AAOS).

Standardized sensorineural tests used in tier 5 assessments of HAVS (thermal aesthesiometry and vibrotactile threshold) are not specific to HAVS, and nerve conduction studies only test the larger diameter fibres that comprise only 20% of the peripheral nerve [xxvi]. However recent evidence suggests smaller diameter fibres (myelinated delta fibres and unmyelinated C fibres) can be damaged in severe CTS possibly explaining the sometimes-reported sensitivity to cold [xxvii]. Testing these small fibres is unlikely to have any practical utility in detecting CTS [xxviii]. Conversely vibration perception thresholds, which test both function of peripheral mechanoreceptors and large myelinated fibres, may be elevated in CTS as well as HAVS. In practice, carrying out tests at both the receptor level (TA and VTT) and the nerve trunk at the wrist level (NCS) is a way of differentiating where the damage has occurred and whether the presenting symptoms reflect HAVS or CTS [xxix]. It remains essential that the results of the tests are considered in the context of those presenting symptoms and associated clinical signs.

9. TREATMENT

Treatment of CTS may include the following.

a. Avoidance of identifiable triggers.

b. Intermittent use of wrist splints – this may be a useful measure recommended by occupational health advisers while the employee awaits further assessment and treatment. Alleviation of symptoms with a splint may also be further evidence for the diagnosis of CTS.

c. Steroid injection – likely to provide temporary relief only and may be useful diagnostically.

d. Surgery – either open or keyhole, with no evidence of one being more effective than the other.

10. WORKPLACE MANAGEMENT

If CTS is suspected:

- Advise the employee to consult a GP to consider further investigation, including multi-segmental nerve conduction tests to assess the severity of CTS and guide treatment.
- If the employee works with vibratory tools, advise employer and worker to:
  - » undertake/update vibration risk assessment and reduce exposure to HTV at work ALARP in accordance with the Regulations, and
  - » undertake an ergonomic risk assessment to reduce the risk of repetitive and sustained forceful wrist activities, particularly with the wrist in a non- neutral position.

If the diagnosis of CTS is confirmed (by clinical or electrophysiological diagnosis or MRI scan):

- Advise the employee to consider alternative work until he/she receives treatment. That may include avoidance of use of vibratory tools.
- Consider advising use of wrist splints.
- Advise employer CTS is a reportable disease under RIDDOR where the person's work involves regular use of percussive or vibrating tools. The employer has a legal duty to report it to HSE once informed of the diagnosis in writing by a medical practitioner.

Following successful treatment of CTS:

- Recommendations for a return to work should be made on an individual basis and the employee should be informed of the possible return of symptoms with continued exposure.
- The employer should be advised to review vibration and ergonomic risk assessments, and to ensure that exposure to HTV at work is reduced to as low as reasonably practicable.
- Consider the need for more frequent health surveillance to identify the re-emergence of symptoms of CTS.
- If there is a relapse of CTS, consider permanent restriction in respect of ergonomic factors and use of vibratory tools.

APPENDIX 1

UK Primary Care Rheumatology Society Diagnosis of CTS

Questions to be asked to a patient presenting with hand or wrist symptoms.

1. Do you have numbness or tingling in your wrist, hand, or fingers?

   If "no" – do not diagnose CTS. If "yes" proceed to ask the following -
2. Do your symptoms spare your little finger?
3. Are the symptoms worse at night?
4. Do the symptoms wake you up at night?
5. Have you noticed your hand is weak; for example, have you found yourself dropping things?
6. Do you find shaking your hand, holding your hand, or running it under warm water improves your symptoms?
7. Are the symptoms made worse by activities such as driving, holding a telephone, using vibrating tools, or typing?
8. Have splints or injections helped with your pain if you have had these in the past?
9. If the first and three or more other questions are answered "yes", or the first and two others with positive Phalen's test, CTS can be diagnosed clinically.

Reference:

Burton C, Chesterton LS, Davenport G
Diagnosing and managing carpal tunnel syndrome in primary care
Brit J Gen Pract 2014; 64: 262-263

APPENDIX 2

The CTS-6 Evaluation Tool

Scores to be assigned for following symptoms/clinical findings

Symptoms	Score
Numbness predominantly or exclusively in the median nerve territory (i.e. the thumb, index, middle and/or ring fingers	3.5
Nocturnal numbness - waking patient from sleep	4
Clinical findings	**Score**
Thenar atrophy and/or weakness	5
Positive Phalen's test	5
Loss of 2-point discrimination at 5mm gap	4.5
Positive Tinel sign	4
Potential maximum score	**26**

Score >12 = 0.80 probability of carpal tunnel syndrome

Score >5 = 0.25 probability of carpal tunnel syndrome

After

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