Supporting occupational health and wellbeing professionals

Vibration-related disease

Drafted by the SOM HAVS Special Interest Group

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1. Introduction

1. The following chapters have 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 hand arm vibration syndrome (HAVS), or at risk of developing HAVS.

2. This guide does not aim to be a comprehensive overview of HAVS, nor does it seek to replace existing guidelines or formal HAVS education. Rather, it is a set of practical summaries intended to provide background information and assist the practitioner who is asked to examine workers exposed to hand-transmitted vibration (HTV). Practitioners seeking to gain further expertise in HAVS are encouraged to undertake further education for the Faculty of Occupational Medicine's certificate in HAVS; HSE guidelines recommend that experience and qualification in occupational health and successful completion of HAVS training is required to undertake formal health surveillance of those exposed to hand transmitted vibration (HTV). A list of additional resources is included for those seeking more detailed information.

3. The individual summaries have been prepared by members of a working group set up by the Society of Occupational Medicine and are intended to represent good practice at the time of publication. However, 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 Society.

4. While the papers are 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 the following members of the HAVS SIG who gave their time and expertise in developing these guidelines:

Professor Jill Belch	Dr Ian Lawson	Dr Minha Rajput-Ray
Dr Kathryn Campion	Dr Chandra Mutalik	Dr Euan Bell
Dr Robin Cordell	Mrs Astrid Palmer	Dr Simon Sheard
Dr Dominic Haseldine	Dr Jon Poole	Dr Danny Wong
Dr Scott Lang	Miss Nikla Rai	Dr Roger Cooke

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 exposed to HTV. They will also be involved in advising employees and employers when there is a need to reduce exposure to vibration so as 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 occasional cases of HAVS, 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.

9. The aim of this document is to provide general advice on HAVS and combine a review of the best available evidence for HAVS 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 include useful tips and advice to avoid common pitfalls.

10. Each section of the document has been written as a standalone paper providing a detailed approach to an aspect of HAVS which can be read independently of the other sections. Also included are some worked case examples as a guide to assist practitioners. The appendices provide supporting information and some templates. This is not a comprehensive review of HAVS, and readers are advised to refer to the additional resources section, and other relevant literature.

11. The document has been developed primarily for occupational health practitioners who are engaged with managing and supporting workers with HAVS and 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, staging and the preparation of management reports. The views expressed do not necessarily represent the views of any particular member of the HAVS Special Interest Group but are considered best practice by members at the time of publication. Members are encouraged to seek further specialist advice where appropriate.

2. EXPOSURE TO HAND-TRANSMITTED VIBRATION

Written by Dr Roger Cooke (March 2018)

2.1. Aims

The aims of this paper are to review the relevance of exposure data to the development of HAVS, describe the principles of measurement, and its application to health surveillance, including consideration of the dose response relationship and putative "no-harm level" of exposure.

2.2. Key messages

- The occupational health professional undertaking HAVS surveillance is expected to understand a vibration risk assessment, including the relevance of exposure levels.
- Assessment of tool emission and exposure time (trigger time) is most effectively done in the workplace under working conditions.
- Use of manufacturers or suppliers' data is appropriate for tool emissions, subject to that data reflecting the intended method of use.
- Retrospective estimates of trigger time by tool operators are unlikely to be accurate.
- There is no accepted method of defining individual risk of developing HAVS, although predictions of population incidence of vascular symptoms are used.
- There is no accepted method of predicting population risk of sensorineural or musculoskeletal symptoms of HAVS.
- There is no accepted level of exposure that is regarded as "safe" for those with existing HAVS.
- A "no-harm" exposure level of 1 m/sec^2 is widely accepted as appropriate.
- Exposure at the Exposure Action Value (EAV - 2.5 m/sec^2) for 12 years is expected to produce symptoms of white finger in 10% of the workforce.
- The over-riding duty of employers, which is not dependent on exceeding the EAV, is to reduce exposure to as low as is reasonably practicable.
- Other duties arise if the EAV is exceeded – including health surveillance.

2.3. Introduction

Development of hand arm vibration syndrome is, by definition, dependent on exposure to hand transmitted vibration having a pathological effect. The relationship between exposure levels and development is not clear, but it is used to estimate population risk of the vascular component of HAVS, and therefore will constitute part of the vibration risk assessment. Regulation 5 of Control of Vibration at Work defines the risk assessment process and states that "the employer shall assess daily exposure to vibration by means of…. reference to relevant information on the probable magnitude of the vibration corresponding to the equipment used in the particular working conditions".

The key factors to be considered when estimating daily exposure to vibration are the vibration emission levels of the various tools used during a day, and the duration of exposure, "trigger time", for use of each of those various tools. Modern vibration measurement equipment allows accurate assessment of the trigger time and level of vibration emitted by the tool. In many cases, both the vibration emissions of the tools and the trigger time are based on retrospective estimates.

Occupational health professionals undertaking health surveillance are expected to be able to understand the likely exposure of an employee. Retrospective determination of long-term exposure, using a range of tools in different jobs, is unlikely to be accurate, and hence conclusions are likely to be indicative rather than definitive.

2.4. The characteristics of vibration

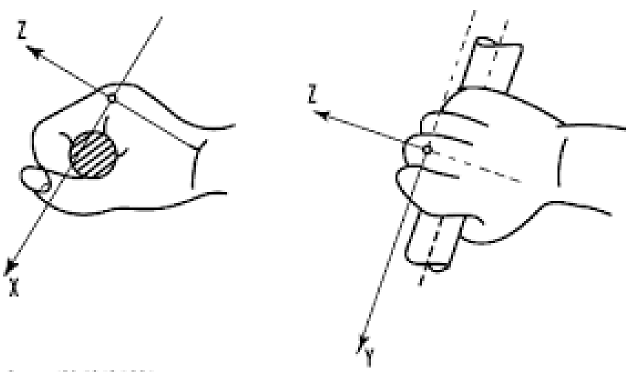
In considering hand transmitted vibration the vibration that is emitted by a tool is described using three key features, being:

a. The direction of vibration being the "x", "y" and "z" axes, as in Figure 1 below. Initial work was based on measurement the level of vibration exposure in the single (dominant) axis, but following the adoption of ISO 5349-1: 2001, the standard method of measurement of such vibration was altered, becoming based on a sum of the vibration in all three axes (tri-axial). This is not an arithmetic sum, but is a root mean square addition. While tri-axial measurement is believed to be a more accurate representation of the total amount of vibration transmitted to the hands, it meant that the figures used to calculate vibration magnitude in this way are not directly comparable with figures derived from dominant axis calculations. It is generally accepted that multiplying the single axis figure by 1.4 gives a broad estimate of the tri-axial measurement.

b. The frequency, measured in cycles per second or Hertz (Hz), is important, with different frequencies being recognised as having greater or lesser health effect. A weighting is given to the frequencies of vibration considered to be most harmful, but this is allowed for in the measurement of vibration and is not generally otherwise quoted.

c. The acceleration is believed to represent the energy level associated with such vibration, and therefore its potential for causing damage. It is generally measured as metres / second/ second or m/sec^2, but levels of vibration exposure may also be expressed using a numerical scale propounded by the HSE, in which exposure is expressed as "points". This method has the advantage that points may be added arithmetically. Equivalent measurements as m/sec^2 and points are shown in Table 1:

Figure 1 – Axes of vibration



Source: ISO 5349 1986.

Table 1 – Acceleration levels and equivalent HSE points

Acceleration - tri-axial measurements m/sec^2	HSE points
1 m/sec^2	16
2.5 m/sec^2	100
3.5 m/sec^2	195
5 m/sec^2	400

d. Intermittent exposure is usually adjusted to an equivalent 8-hour exposure level, to allow for further standardisation in assessment of risk; this is known as the A(8) level. Some of the early work relating to exposure focused on 4-hour exposures, so it is important to be clear which exposure period is being used. Hence daily exposure will usually be expressed as m/sec2 daily A(8), or points per day.

2.5. Measurement of vibration emissions from tools

Vibration is measured using an accelerometer, attached to the tool. Modern equipment will measure vibration in each of the three axes, and give a tri-axial sum, as well as measuring the duration of use, and therefore the total dose. Use of personal dosimeters takes that a stage further by allowing measurement of an individual employee's exposure when using several different tools. Because it measures all these aspects of vibration exposure for the individual employee, this is likely to be the most accurate method of estimating exposure.

While direct measurement of vibration emissions from tools is ideal, HSE guidance is that "you may choose either to use available vibration data or to have measurements made to estimate exposures if you want to be more certain whether the risk is high, medium or low". However it is noted that "if you plan to use the manufacturers vibration data you should check that it represents the way you use the equipment …since some [manufacturers' vibration] data may underestimate workplace vibration levels substantially" and "if you are able to get vibration data from the manufacturer which is reasonably representative of the way you use the equipment, it should be suitable for you to use in estimating your employees exposure". Because vibration emissions from tools will vary according to (for example) the substrate on which they are being used, it is important that any generic tool vibration levels, whether from HSE data, commercially available databases, or manufacturers or hirers, are confirmed as being appropriate to the specific circumstances under consideration.

2.6. Duration of exposure ("trigger time")

The HSE recommend that where direct measurement of trigger time is not possible, the employer should "check by observing them how long employees are actually exposed to the vibration (since) employees are unlikely to be able to provide this information very accurately themselves". Where neither direct measurement nor observation is possible, retrospective assessment of trigger time may be required. The tendency for operators to over-estimate exposure time in such circumstances has been known for many years.

HSE Contract report 232 in 1999[1] commented among their conclusions that "workers tend to systematically overestimate the duration that they are exposed to HTV". The authors note that "the errors may not be large in relation to other sources of error in dose estimation. Nevertheless, tables that contain quantitative estimates of exposure must be regarded as indicative rather than definitive".

In 2000 the same group of authors published a paper which assessed self-reporting of occupational exposure to hand transmitted vibration[2], and stated that they found that workers overestimated their duration of exposure to hand transmitted vibration by a factor of 2.5 (interquartile range 1.6-5.9), with estimated duration of exposure being more accurate when the exposure was relatively continuous rather than for intermittent short periods. A small study of men using grinders was published in 2005 and concluded that estimates of exposure by the workers was about four-fold higher than estimated mean exposure by objective means[3], and in 2011, a study of dental hygienists found that "although the exposure times were short, the self-assessed duration of exposure was overestimated on average three times higher with a diary and even more at an interview (8 times)"[4].

1. Palmer KT, Coggon D, Bendall HE and Pannett B
Hand transmitted vibration: occupational exposures and their health effects in Great Britain.
HSE Contract Research Report 232/1999

2. Palmer K, Haward B, Griffin M, Bendall H, Coggon D
Validity of self-reported occupational exposures to hand transmitted and whole-body vibration.
Occup Environ Med 2000; 57: 237-241

3. Gerhardson L, Balogh I, Hambert PA et al
Vascular and nerve damage in workers exposed to vibrating tools: the importance of objective measurements of exposure time.

4. Akesson I, Balogh I, Skerfving
Self-reported and measured time of vibration exposure at ultrasonic scaling in dental hygienists.
Applied Ergonomics 2001; 32 (1) 47-51

2.7. Calculating exposure

As noted above, use of personal dosimeters allows the vibration dose to be clearly measured. Where such equipment is not used, but an estimate of exposure from a number of different tools is required, using tool emission and trigger time data, the total exposure can be calculated by adding the exposure from each individual tool together; however that is not a simple arithmetic calculation, and a much easier alternative is to use the calculator developed by HSE and available on-line.

Table 2 – HSE vibration calculator *(Source: https://www.hse.gov.uk/vibration/hav/calculator-guide.htm)*

HSE

HAND-ARM VIBRATION EXPOSURE CALCULATOR Version 6.3 September 2023

Company name/work area:

Employee ID and/or task name:

Tool Use drop-down list for HSE recommended initial tool magnitude value (range for tool shown in brackets) or manually add tool type and/or magnitude in this column and the Vibration magnitude in "User" column.	Vibration magnitude m/s²		Task Points per hour	Time to reach EAV hh:mm	Time to reach ELV hh:mm	Exposure duration		Partial exposure m/s² A(8)	Partial exposure Points
	HSE	User				hours	mins.		

	Daily exposure m/s² A(8)	Daily exposure points
INSTRUCTIONS: Enter vibration magnitudes and exposure durations (for an individual worker or a task carried out by several workers) in the white areas. Results are displayed in the yellow areas. Additional information such as company name, worker name may be added if printing or saving the calculation.		

Exposure calculation by:		**Calculation date:**	10/09/2024
Job role:			

2. 8. Other factors affecting individual exposure

A number of additional factors must be considered when assessing and reducing exposure to vibration. Correct use of any tool is important, with incorrect use having potential to increase the level of vibration produced by the tool or task or transmitted to the hands.

"Coupling" is the degree of contact between the tool and the hand, which will influence the amount of vibration absorbed by the hand. Appropriate training is likely to reduce the adverse effects of these issues.

Personal protective equipment is not usually a realistic option for controlling vibration exposure; although "anti-vibration gloves" are often discussed, there is little evidence that they have consistent benefit.

2.9. The "no-effect" level

In 2002, the EU Directive[5] defined a threshold level of 1m/ sec2 daily A(8) as "the exposure value below which continuous and/ or repetitive exposure has no adverse effect on the health and safety of workers". Early work by Brammer had "suggested the possibility of a no effect level of exposure in the range 1m/s2< ak < 2m/s2 where ak is the single axis, frequency weighted acceleration magnitude"[6], which was reflected in ISO 5349-1:2001, which states that "reports of ill-health are rare below 2m/s2 A(8) and not known at exposures below 1m/s2 A(8)".

A 2015 review concluded that they had "not found any recent evidence to either substantiate or refute this implied no-effect level."[7] The earlier evidence reviews for the Faculty of Occupational Medicine[8] had noted that "a review of early epidemiological data suggested that there is an exposure threshold between 1-4 m/sec^2 over a working lifetime where it is unlikely to result in either sensory or vascular symptoms. This has led to the use of 1 m/sec^2 (frequency weighted) as a supposed conservative threshold for defining hand transmitted vibration exposure or tool emission below which concerns about HAVS may be unwarranted."

In 1998, Bovenzi reported a study of point prevalence of vascular HAVS in a total of 882 users of vibrating tools concluded that the prevalence in the control group of 455 manual workers and the group exposed to less than <1m/ s2 were not significantly different[9].

In respect of individuals who have already developed symptoms of HAVS, there is no consensus as to what constitutes a "safe" level for continued exposure, which must therefore remain a matter of clinical judgement until further evidence is available.

2.10. The dose response relationship

There is insufficient evidence to define a vibration dose-response relationship for either the sensorineural component of HAVS or the various musculoskeletal symptoms that may be caused by exposure to hand-transmitted vibration. Although there is general agreement that lifetime accumulation of vibration exposure contributes to the development of symptoms, and there has been considerable work looking at the basis of a dose-response relationship for the vascular component (vibration white finger), definition of the precise relationship has been elusive.

Based on Brammer's work, the level of 2.8m/sec^2 (single axis) quoted in HS(G) 88 was recognised as producing vascular symptoms in 10% of an exposed population over a period of exposure of 8 years. In comparison ISO 5349-1 refers to a level of exposure of 3.7 m/sec^2 (tri-axial) producing vascular symptoms in 10% of people in 8 years. This illustrates that a tri-axial measurement of 3.7m/sec^2 is believed to have the same health effect as a dominant axis measurement of 2.8 m/sec^2.

2.11. Legal issues

The Control of Vibration at Work regulations were introduced in the UK in 2005, under the umbrella of the Health and Safety at Work etc. Act 1974. Those regulations were accompanied by HSE guidance – document reference L140. Prior to that employers had a general duty under the Health and Safety at Work etc. Act, with specific guidance available through HSE document HS(G) 88 – Hand Arm Vibration,

5. EU Directive 2002/44/EC – Physical Agents (Vibration) Directive
6. Brammer Hand-Arm Vibration 1990 pp291-299, publ. Wiley-Interscience
7. Hewitt S, Mason H A critical review of evidence related to hand arm vibration syndrome and the effects of vibration RR1060 publ HSE Books 2015
8. Mason H, Poole K Clinical Testing and management of individuals exposed to hand transmitted vibration Faculty of Occupational Medicine 2004 ISBN 1-86016-203-7
9. Bovenzi M (1998) Vibration induced vibration white finger and cold response of digital arterial vessels in occupational groups with various patterns of exposure to hand-transmitted vibration. Scand J Work Environ Health 24: 138±144

first published in 1994. In November 2010 the HSE produced a Topic Inspection Pack for HAVS, which "provides guidance for (HSE) inspectors on the inspection of work activities involving risks from hand arm vibration (HAV) and on enforcement of the Control of Vibration at Work Regulations". This was superseded in 2020 by HSE document "Hand-arm vibration: Inspection and Enforcement Guidance", which is currently available on the HSE website at https://www.hse.gov.uk/foi/internalops/og/ index.htm

Regulation 4(1) of the Control of Vibration at Work Regulations define a daily exposure of 5 m/s^2 A(8) (equating to 400 points on the HSE scale) as the maximum amount of vibration an employee may be exposed to on any single day (i.e. the exposure limit value – ELV) and a daily exposure of 2.5 m/s^2 A(8) (equating to 100 points on the HSE scale) as the daily exposure action value (EAV). However, the key requirement of the regulations is to reduce exposure to as low as is reasonably practicable. That is not dependent on the existing level of exposure and applies whether or not the EAV is exceeded.

Conclusions regarding exposure levels compared with the EAV exposed above or below the EAV, will determine statutory responsibilities in respect of issues such as the provision of suitable health surveillance, and the provision of suitable and sufficient information instruction and training. It is important to note that that the EAV (2.5 m/sec^2) is not in itself a safe level of exposure, in that at that level a 10% of the workforce exposed to vibration for 12 years are likely to develop finger blanching. However, it is also important to note that at this level 90% of the exposed workforce will be expected not to develop symptoms of vascular HAVS.

2.12. Reduction of exposure to as low as reasonably practicable

The reduction of exposure to a level that is as low as reasonably practicable is not defined in terms of specifying levels of vibration, since, by definition, it requires an assessment of both the risk – and therefore of the level of vibration exposure – and of the sacrifice in money, time and trouble, involved in taking measures to avoid that risk, and a comparison of the two.

The HSE[10] has identified that there is little guidance from the courts as to what reducing risks as low as is reasonably practicable means and refers the Court of Appeal judgement in Edwards v. The National Coal Board, which related to whether or not it was reasonably practicable to make the roof and sides of a road in a mine secure. The judgement was that "… in every case, it is the risk that has to be weighed against the measures necessary to eliminate the risk. The greater the risk, no doubt, the less will be the weight to be given to the factor of cost," and that "'reasonably practicable' is a narrower term than 'physically possible' and seems to me to imply that a computation must be made by the owner in which the quantum of risk is placed on one scale and the sacrifice involved in the measures necessary for averting the risk (whether in money, time or trouble) is placed in the other, and that, if it be shown that there is a gross disproportion between them – the risk being insignificant in relation to the sacrifice – the defendants discharge the onus on them."

It follows from that that the level of vibration that constitutes "as low as reasonably practicable" will vary from one industry to another, and from one organisation to another. Even within a single organisation, different circumstances may lead to different conclusions as to what is reasonably practicable in those particular circumstances. Given that the duty is to reduce exposure to a level that is low as reasonably practicable, exposure to a level greater than the EAV does not in itself constitute a breach of that duty, and conversely reduction to a level below the EAV does not in itself indicate compliance.

10. HSE website - http://www.hse.gov.uk/risk/theory/alarp1.htm#P14_1686

3. RISK ASSESSMENT FOR HAND-ARM VIBRATION SYNDROME

Written by Dr Jon Poole (September 2018) / Updated by Dr Roger Cooke (December 2020)

Advice on how to undertake a risk assessment (RA) for HAVS can be found in the HSE Guidance Hand-arm vibration: The Control of Vibration at Work Regulations 2005 (L140 – 2020), under Regulation 5, pages 11-15.

The key elements to look for in a risk assessment are:

- Is it based on observed working practices in the workplace rather than being generic in nature?
- Does it state who might be affected by exposure (jobs or names) to hand-transmitted vibration (HTV)?
- Is there information about magnitudes of vibration from the tools being used (taken from manufacturers' data, databases of typical magnitudes, or from actual workplace measurements)?
- Is there information (measured or estimated) about typical daily contact (trigger) times with each tool for the exposed workers?
- Is there a calculation of daily exposure to HTV (the HSE's on-line vibration calculator is a good way of doing this)?
- Is exposure to HTV set in the context of the daily Exposure Action Value (EAV) and the Exposure Limit Value (ELV)?
- If the EAV has been exceeded, what control measures have been instituted?
- Are there any workers with increased susceptibility to HTV? If so, how is the risk to these individuals being managed?
- Are there workers exposed to cold or wet conditions which are more likely to trigger vasospastic episodes? If there are, how is this reflected in the risk assessment (RA)?
- Does the RA indicate the need for health surveillance (HS) and if it does, have the results of previous HS been taken into account in the RA? That is, does it state whether there are cases of HAVS in the workforce?
- If there are five or more employees, then the RA should be in writing. Any worker with increased susceptibility to HTV should be considered in the RA or have their own separate RA.
- Is there a date for review and is the name of the person who did the RA stated?
- Have the workers or their representatives been involved in the RA (for example, daily contact times) and has it been shared with them?

4. HAND ARM VIBRATION SYNDROME: TIERED HEALTH SURVEILLANCE

Written by Dr Ian Lawson and Dr Jon Poole (March 2019)
Updated by Dr Roger Cooke (January 2023)

It is a requirement of the Control of Vibration at Work Regulations 2005 (CVAWR) for employers to provide health surveillance for employee who are regularly exposed at or above the Exposure Action Value of 2.5m/sec^2. The guidance to these regulations (L140) recommends a multi-tiered approach to health surveillance consisting of 5 levels. The aim at each tier is to detect potential cases of HAVS as early as possible and provide suitable advice on management (see section 8).The severity of HAVS, as currently designated in HSE guidance L140, is staged by the use of a modified Stockholm Workshop Scale (SWS). (See section 9 on Staging).

An important aim of health surveillance for HAVS is to prevent any worker reaching stage 3v or stage 3sn. Following the onset of stage 2 HAVS, the frequency of health surveillance should be increased, with the aim of detecting further progression. The frequency of such increased surveillance is a judgement by the senior OH clinician responsible for that employee.

Tier 1 Initial questionnaire prior to exposure to vibration. The completed tier 1 questionnaire should be sent in confidence to an occupational health professional, as they may contain individual medical details. Tier 3 assessment is required if there are any positive answers. Advice about working with vibration should be offered to the employer based on the tier 1 responses.

Tier 2 questionnaire should be used at least annually. Earlier assessment (at six months) is recommended for newly exposed employees to identify susceptible individuals. Any reporting of relevant symptoms should lead to tier 3 assessment.

Questionnaires for Tiers 1 and 2 can be given out by a Responsible Person, but HSE recommend that the completed tier 1 forms should be regarded as confidential and sent to an occupational health professional for assessment. The employee should be offered the alternative of the completed tier 2 form being forwarded to an occupational health professional in the same way, in order to preserve confidentiality of personal health information, and any tier 2 forms with positive answers should be forwarded to a Qualified Person for interpretation, and employment advice pending full assessment.

Tier 3 (clinical assessment) is undertaken by a registered nurse holding qualifications in occupational health and who has successfully completed a Faculty of Occupational Medicine approved course on HAVS.

It is required if there are positive responses to questions on the tier 1 or tier 2 forms. In the absence of self reported symptoms there is no need for referral to tier 3. This represents a change from the 2005 guidance L140 which recommended tier 3 assessment after negative responses for three consecutive years at Tier 2, which is therefore no longer recommended by HSE Guidance.

Where the tier 3 assessment concludes that the symptoms are compatible with or suggestive of HAVS or CTS the employee should be referred for tier 4 assessment as soon as possible. HSE guidance recommends that the employee should be assigned to alternative work with restricted or no risk from further vibration exposure pending formal (tier 4) diagnosis.

Tier 4 Diagnosis of HAVS or CTS by an occupational physician who has a qualification in occupational health and has successfully completed a Faculty of Occupational Medicine approved course on HAVS.

Diagnosis of HAVS or CTS will reflect the judgement of the doctor, and may trigger consideration of alternative work or restriction of vibration exposure. If employment criteria are met a diagnosis will lead to recommendation that the employer makes a RIDDOR report.

Tier 5 Quantitative sensory tests and Tier 5 referral criteria

The weaknesses of the SWS, the modified SWS and the role of quantitative sensory testing have been the subject of recent publications which may inform future guidance.[11,12,13] However, at present OPs using extant guidance may be faced with clinical uncertainty or difficult decisions on recommending ongoing vibration exposure. In these cases referral to a doctor experienced in HAVS and/ or a tier 5 HAVS centre may provide useful support.

The following referral criteria for tier 5 assessment are good practice but should not be viewed as fixed referral criteria.

i. If there is doubt about the diagnosis of HAVS.

ii. Suspected stage 2SN (early or late) or stage 3SN cases as such a staging can led to redeployment or job loss. For this reason it should be done as accurately as possible.

iii. Rapidly progressing symptoms, signs or disability associated with HAVS.

iv. Challenging cases such as those with CTS and suspected co-morbid sensorineural HAVS, or those with vascular HAVS and an abnormal Allen's test.

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5. HAND ARM VIBRATION SYNDROME: TAKING THE HISTORY

Written by Dr Ian J Lawson (July 2018)

5. 1 Introduction

A number of questionnaires have been developed to assist in the history taking and examination of possible cases of HAVS at tier 3 and 4 level health surveillance. The questionnaire in HSE Guidance L140 is the most commonly used. Whilst these include all relevant questions the format can sometimes lead to a disconnection between sections where linkage is key to making an appropriate conclusion. The purpose of this document is to provide additional guidance on these key issues and linkages in the history and examination and how these should be assimilated with the overall assessment.

The order that histories are taken can be a personal preference such as occupational history first followed sensory then vascular symptoms and the order of headings here are for convenience. A lot of useful information can be gathered by self-administered Katz diagrams of symptom patterns. These can be sent out for completion prior to the appointment (an example is shown in the appendix which can also be set out to personal preference).

5.2 Vascular symptoms

- Ascertain by open history whether episodic vasospastic whiteness is occurring (starting distally in one or more fingers, usually circumferential, demarcated whiteness and not a description involving the whole hand, blotchiness or physiological vasoconstriction).

- Photographs, usually from a phone should be requested ahead of the face-to-face appointment whenever possible. These should be identifiable as the individual's (compare with hands in situ or taken against the face). Also have a catalogue of photos showing normal/vasospastic fingers to be shown to the employee. (See section 7 on photography)

- Whilst circumferential whiteness is the usual description provided with Raynaud's phenomenon it can sometimes just affect one side of the digit.

- Ask whether the nails are affected. Blueness alone is sometimes described by some and is acceptable.

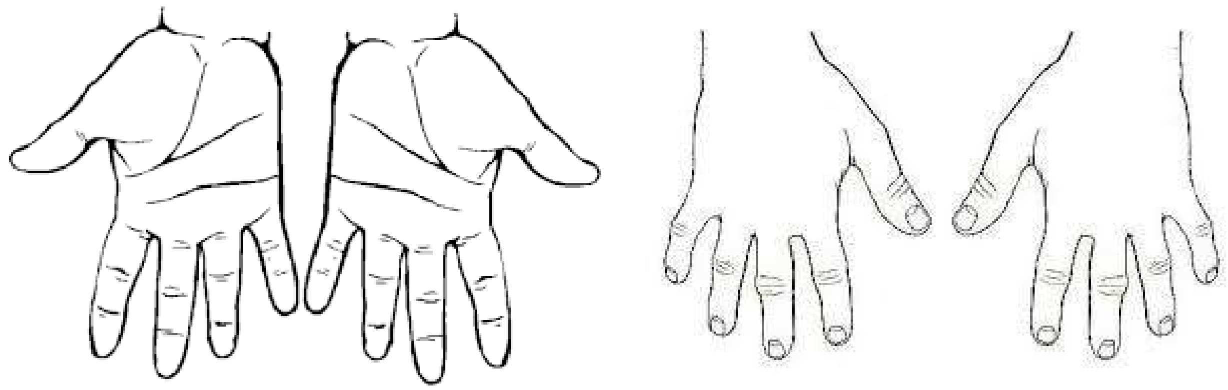
- What other associated symptoms are reported with vasospasm; finger numbness or tingling; redness; blueness; pain; 'hot aches' at end of attack (bi-and tri-phasic descriptions are rare in practice). How long lasting are the episodes of blanching.

- It is very important to determine date of onset as precisely as possible (not just when the worker became aware of a problem). The circumstances associated with attacks (cold or otherwise; emotion; pressure; whilst using vibrating tools is unusual unless cold exposure or cold tool surface or exhaust air). How did it commence; fingertips initially or all of fingers (initial extensive vasospasm more suggestive of Raynaud's disease or some other cause of secondary Raynaud's phenomenon).

- Note what aggravates an attack such as cold or damp working conditions. How has it progressed from the onset of symptoms and are symptoms worsening or remaining the same. With regard to attack frequency note the worst-case scenario in the cold (per week/ month/year), and, if all year round, frequency both in winter and summer. Note when the last attack was (n.b. classed as inactive if none for 2 yrs). Attacks usually last between 20-30 minutes but can range from a few minutes up to 2 hours (possibly think of alternative diagnosis if >2hrs). Summertime episodes when evenings cool probably indicative of progression of the condition although there is no absolute temperature and the relative change in ambient temperature can be enough to precipitate an attack.

- Enquire if other peripheral parts of the body are affected by colour changes particularly the toes. A description of cold feet, just like cold hands, may be normal. Whiteness of toes if described does not exclude HAVS if fingers affected but think of possible primary Raynaud's phenomenon.
- How many fingers are affected in a typical attack (document worse case); number of episodes in cold weather.
- Shade in and document as below.

Figure 2: Pictograms used for illustrating the distribution of vascular and sensory symptoms



- Again enquire about the onset and progression of each (be aware of vernacular idioms when taking a history as terms N & T may not be readily understood ('crawling', 'fat' fingers, 'buzzing', 'electric shocks').
- Documentation of fingers affected and aggravating circumstances as with vascular. Tingling that occurs after using vibrating tools is physiologically normal and generally accepted as ceasing after 20 minutes (Temporary Threshold Shift, TTS).
- Some describe symptoms that occur intermittently and others a more persistent awareness. Enquire about the effect of periods away from work has on symptoms. Again prior hand pictograms are valuable particularly in ascertaining the true distribution.
- A mono-neuropathy may be present (median or ulnar) but caution against textbook descriptions of nerve distribution (i.e. forearm and palmer median to ulnar nerves frequently anastomose, Clark 2011. Remember to relate symptoms to the type of tool usage and exposed fingers/thumbs (n.b. thumbs generally not affected in most power tool grips as separated by other fingers).
- As the neuropathy progresses there is loss of sensibility and manual dexterity loss. Other symptoms such as pain, stiffness or swelling of fingers/hands/wrists should be documented.
- Note the aggravating circumstances such as work with vibrating tools, certain forceful gripping or particular work activities. How have symptoms progressed and are they worsening or improving. Note any interference with social activities such as hobbies.

- If nocturnal symptoms enquire if woken by or is merely noticed if wake for other reasons. The former is more indicative of an entrapment neuropathy.
- 'Fetal' sleepers and those who swap hands when using a mobile phone because of sensory symptoms is suggestive of cubital tunnel syndrome. (Cutts 2007). If problems with dexterity, ask for examples which should be readily forthcoming.
- Grip is often reduced in those working with vibrating tools but its association to HAVS is unclear but functional effects are important to describe particularly any workplace limitations or potential safety issues. Enquire regarding functional effects on activities of daily living.

5.3 Past medical & social history

A. **Vascular** Raynaud's disease or Primary Raynaud's phenomenon (common, symmetrical, prior to exposure, other periphery, family history, stress). N.B. 15% of carpal tunnel syndrome (CTS) cases have Secondary Raynaud's phenomenon,RP (Hartmann 2012). Other causes of secondary RP include connective tissue disorders Less common causes of vascular symptoms may include; acute injuries, non-freezing cold injuries (NFCI), thoracic outlet syndrome (TOS) (suspect from history of neurovascular symptoms on arm elevation), thrombo-embolism, cold haemagglutinin disease (CHD) or cryoglobulinaemia (suspect if cyanosis or blotchy whiteness in non-cold exposure or history of Hep C).

B. **Sensory** Entrapment neuropathy: carpal tunnel syndrome (CTS) and cubital tunnel syndrome (CBTS) are the commonest (CTS 4 to 1 CBTS). An ulnar neuropathy at the level of the wrist maybe part of a hypothenar hammer syndrome (HHS). Cervical spondylitis with radiculitis (symptoms may worsen on neck movement). Diabetic neuropathy; usually not presenting until 10 years plus from onset and being 'length-dependant' does not usually affect hands ('glove') if feet ('stocking') not present (Watson 2015). Other conditions to consider are peripheral vascular disease and systemic conditions such as MS or CVA.

C. **Medication** Vasoactive drugs. Non-selective beta- blockers commonest (note onset of symptoms with use of; other periphery often affected but can be confined to the hands in 50% of cases). CTS also reported at increased risk if taking non-selective beta-blockers Drugs affecting nervous system e.g. metronidazole.

D. **Operations/ Fractures / X-rays** Injuries/fractures; lacerations can leave sensory deficit but usually detected/ reported at time of injury. May have been told had cervical rib on Chest X-Ray.

E. **Family History** If Raynaud's phenomenon (Usually 1st degree but can skip a generation), CTD, 'Vibration White Finger', CTS, Dupuytren's(DC).

F. **Dominant hand** Left / Right / Ambidextrous

G. **Hobbies** that include HTV exposure. How symptoms affect hobbies. HTV outside work (motor bike, chainsaws etc.) unlikely to be relevant unless excessive.

H. **Smoking** Smoker/Ex-smoker/Non-smoker. Effects of smoking on HAVS minimal. Reported increased OR for CTS (Pourmemari 2014)

I. **Alcohol** Units per week. Excessive may lead to an alcoholic neuropathy

5.4. Occupational History

There is separate guidance on HTV exposure and the purpose of this section on history taking is to focus on the linkage with other aspects of the history. There can often be an extensive occupational history of HTV so that gathering basic details prior to the appointment can be time saving (see separate proforma in the appendix).

- Time should be spent at interview gathering information on what the 'trigger' times are likely to be given that most overestimate their exposures. Is there any asymmetry of exposure; ask whether there is a perception of greater exposure on any particular hand/fingers. Relate this to symptomatic hands and fingers. Depending on the task/s either leading hand or trigger hand/fingers may be exposed to higher levels of exposure. Hygiene data on measurement levels may help as does a workplace visit. The temporary threshold shift (TTS) described after finishing a task can also assist in lateralising exposures. It is helpful to have a catalogue of commonly used tools as many workers use local idioms to describe tools they use. Explore how the exposure relates to symptoms in terms of onset, progression and improvement when away from certain tasks or on holiday.
- It is key in this section to ascertain when vibration started and if no longer used when it was reduced or ceased.
- If thumbs are symptomatic see if the grip used may be relevant i.e. tripod grip in pedestal polishing. Enquire about whether the hand/palm surface has ever been used like a hatchet to strike components or workpieces (if HHS is a possibility).
- This section should include enquiry about potential neurotoxic exposures.
- HTV measurements: if known or presumed from supplier data. Convert to points if preferred; Points per hour PE,1h = 2a2 ; Consult EU Good Practice Guide HAV on commonly used tools typical ahv values. 'Average': can be estimated A(8) by HSE calculator.
- Leading hand: this is the hand/fingers closest to vibration-workpiece interface.
- Trigger: the hand/fingers closest to the source of the vibrating tool.
- Anti-vibration devices/ gloves: although anti-vibration gloves not generally able to reduce harmful vibration frequencies. May be an indication of employer support and useful if cold workplace and tools.
- Shifts/overtime/periodic work: to take account of any potential additional or intermittent exposures.
- High pressure hose/ impact activity: high pressure hoses such as sand or wet blasting have been shown to produce potential harmful levels of HTV.

Received damages at Common Law or Industrial Injury Disablement Benefit:

This question may be seen as intrusive and unnecessary in the context health surveillance, but it is still part of a confidential medical assessment. An outstanding claim or assessment for IIDB may be relevant to the overall presentation and assessment: however enquiry is for the individual OP to decide if relevant.

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6. HAND ARM VIBRATION SYNDROME: CLINICAL EXAMINATION

Written by Dr Ian J Lawson (July 2018)

There are usually few signs to help in diagnosis of HAVS, other than excluding CTS and other differential diagnoses (annotate hands where appropriate).

1. **Temperature of hands:** note if cool after acclimatisation at room temperature (caution - normal finger skin temperature (FST) 30°C - 34°C and perception depends on observer's normal FST. Thermocouple preferable).
2. **Colour:** vasospasm unlikley but note any acrocyanosis (cryoglobulinaemia?) or trophic changes (connective tissue disease ?).
3. **Scars:** very old injuries often fogotten in history taking so enquire re forearm, hand and digitial injuries. Latter can particularly impact on Quantitative Sensory Testing (QST).
4. **Callosities:** volar distribution usually reflected in active working hands. Note any mismatch between findings and reported disability (disappear after 3 months inactivity). Actual callosity on fingertips between tip and whorl is unusual in manual workers although some thickening of skin may be detected.
5. **Muscle wasting:** Thenar/Hypothenar/Dorsal interossei; Wasting of thenar more a dip or crescent shaped groove at outer edge of muscle bulk than a flattening (median nerve) and best seen from above with hands in 'prayer position'. First dorsal interossei most noticeable if muscle loss is present (ulnar/ cubital tunnel problem).
6. **Cervical Spine / upper limb movement** / cervical rib / joint swelling / pain/ stiffness; check normal range of movement in neck and upper limb joints and note any reproduction of symptoms. Note any swelling, deformity or stiffness (RA or osteoarthritis is a risk factor for CTS). Subluxing ulnar nerve at elbow increases risks of cubital tunnel syndrome.
7. **Dupuytren's/Trigger finger:** thickening, nodules, cords, or deformity of DC. Trigger Finger TF; tenderness or nodules over A1 pulley or overt triggering (CTS, DC and triggering often occur together and may suggest idiopathic association).
8. **Power:** general power grip of examiner's two fingers (ulnar); abductor pollicis brevis (point thumb away from horizontal palm towards ceiling and push against) and dorsal interossei (kept fingers spread apart and push against) for median and ulnar nerves respectively (n.b. add Froment's sign if interossei appear weak).
9. **Pulses / Blood Pressure:** standard Allen's (or Doppler assisted if available) / Adson's or Roos (if indicated by history
10. **Tinel's:** tapping lightly over nerve at wrist (distal volar skin crease- median nerve) and elbow (cubital tunnel –ulnar). **Phalen's:** passively flexed wrists positive if provoked within 60 seconds. Caution over reported sensitivity and specificity of these two tests.
11. Add **fixed flexion test at elbows** if suspect cubital tunnel syndrome (elbow flexion, wrist extension for one minute; positive if paraesthesia in ulnar nerve distribution).

7. THE USE OF PHOTOGRAPHY IN DIAGNOSIS AND STAGING OF HAVS

Written by Dr Roger Cooke

The vascular component of hand-arm vibration syndrome (HAVS) is manifest as Raynaud's phenomenon (RP). In the absence of any reliable objective diagnostic test for vascular HAVS, diagnosis is based primarily on the history obtained from the employee. A history of RP has been described as the gold standard for diagnosis of vascular HAVS[1]; in the UK, the Health and Safety Executive (HSE) have emphasised the need for a sufficiently detailed history of the attacks of blanching to differentiate RP from a normal physiological response to cold.[2]

In 2014 an international Delphi exercise concluded that at least biphasic colour changes are required to make the diagnosis of RP – with white/pallor and blue/cyanosis being the two most important colours to make a diagnosis – with triphasic changes increasing the likelihood of RP.3 Photographs of episodes provided by patients were "thought to be helpful but not required to make a diagnosis of RP".

A review of 36 cases of photographs taken in possible HAVS cases found that, on careful history taking, 11% had symptoms that were not consistent with RP, and 40% were unable to provide photographic evidence of RP.[4] The study group comprised individuals making a claim for HAVS, so it is unclear whether those results can be extrapolated to those undergoing routine health surveillance. Nevertheless, a photograph of the employee's hands/digits during an attack of colour change is potentially strongly supportive that true vasospasm is being described.

Another Delphi study recommended that a blanching score taken from photographs of the hands during vasospastic episodes be used to stage vascular HAVS in place of self-recall and frequency of attacks.[5] However, it is possible that such photography may not capture all affected fingers during a single attack, so reliance on this for staging may not be universally appropriate. It also raises the important question of whether or not a definitive diagnosis and/or grading can be offered in the absence of such photographs.

Shortly after that, a review of the assessment and objective testing in the vascular component of HAVS by the Industrial Injuries Advisory Council recommended the use of photography and concluded that "photographs will be suitable only to supplement the patient's description of their symptoms and relationship with work and exposures, but will not be sufficient on their own to replace this evidence".[6]

Diagnostic criteria for HAVS were defined in the Court of Appeal judgement in Montracon Ltd v Whalley[7] as being:

- a history of exposure to vibration sufficient to cause a risk of development of the condition
- a clinical history of symptoms which is consistent with one or more of the components of HAVS
- the absence of any alternative explanation for the symptoms.

As it was not relevant to this case, the Court of Appeal did not consider the use of photography, but taken at face value, the second criterion requires only a "clinical history of symptoms which is consistent with one or more component of HAVS", inferring that photography or observation of an episode of Raynaud's phenomenon is not essential to meet these legally defined diagnostic criteria. Nevertheless, requests for photographs are now common in the course of civil litigation.

Whether for legal purposes or for routine health surveillance, the diagnosis of vascular HAVS based on the clinical assessment alone (i.e. without photographs or witnessed episodes of Raynaud's phenomenon) can be made to different levels of confidence:

1. **Beyond reasonable doubt**
2. **Probable, i.e. "on balance of probability"**
3. **Possible**
4. **Not suggestive of HAVS.**

Diagnosis made clinically beyond reasonable doubt

In cases with a clear history which includes the characteristic features of Raynaud's phenomenon, with an appropriate temporal relationship with lifetime (cumulative) vibration exposure, a distribution according with likely differential vibration exposure of the digits and no evidence of a plausible alternative cause of the symptoms, clinical diagnosis may be made beyond reasonable doubt. In spite of this, where the clinical presentation is sufficient in itself to make a diagnosis, photographs are likely to be useful confirmatory evidence and provide a record for future comparison.

In these cases, even in the absence of a photograph, diagnosis and grading can be offered, along with advice regarding further exposure to vibration, and that diagnostic criteria be met for the purposes of RIDDOR.

Diagnosis of vascular HAVS probable, i.e. "on balance of probability"

It is possible that the description of colour changes is not typical, or is insufficient to allow confident diagnosis, and photographs of the colour changes experienced by the employee would likely provide clarity. Nevertheless if, on balance of probability, the diagnosis based on the clinical description is of HAVS, the diagnosis should be confirmed on that basis.

If photographs are then provided which show that colour changes are not consistent with RP, the diagnosis and grading should be reviewed by a senior occupational health physician with experience in HAVS. Particular care should be taken to ensure that photographs are taken during the blanching phase of an attack, and do not show, for example, blotchiness associated with reperfusion. Where photographs provide good evidence of RP, and other factors are compatible with the diagnosis, HAVS should be confirmed.

Workplace advice, and advice regarding continuation of vibration exposure should be offered on the basis of the clinical diagnosis, pending receipt of photographs. The diagnosis means that the HAVS criteria for RIDDOR are met.

Possible diagnosis of HAVS

In these cases, the clinical history, including description of colour changes is such that a diagnosis is not appropriate. Full assessment is likely to include photographs of the colour changes experienced by the employee, but may also require consideration of alternative diagnoses and appropriate investigation, e.g. for carpal tunnel syndrome or connective tissue disease.

A diagnosis of HAVS is not appropriate:

a. where the clinical history does not lead to a diagnosis of RP and there is no photographic evidence

or

b. where the history does not suggest RP and (subject to the above caveat re timing of the photograph) the photographs do not show characteristic colour changes.

The absence of confirmed diagnosis means that the HAVS criteria for RIDDOR are not met. However, the nature of the symptoms reported may be such that advice is required regarding further vibration exposure. That will be a matter of clinical judgement. Where the history and photographs are more suggestive of primary Raynaud's, or other secondary Raynaud's, workplace management may be similar to that for HAVS. This will be a matter for senior clinical judgement.

Where there is no description of characteristic colour changes but photographs show typical blanching of RP, clinical review should be undertaken without delay by a senior occupational physician with experience in HAVS.

Description of colour changes not suggestive of HAVS

In these cases, alternative diagnoses should be considered. Photographs of colour changes may be helpful and could potentially influence the judgement as to whether or not the diagnosis should be reviewed on that basis. As in the previous category, where there is no description of characteristic colour changes, but photographs show typical blanching of RP, clinical review should be undertaken by a senior occupational physician with experience in HAVS.

RECOMMENDATIONS

Photographs, usually from a phone, should be requested ahead of the face-to-face appointment whenever possible.[8] These should be identifiable as the individual's (compare with hands in situ or taken against the face) although it has been noted that since an individual's hands are unique it may be possible to make confident identification that the hands in the photograph are those of the employee concerned.

Copies of the photographs should be retained in the employee's occupational health record, and should be accompanied by a record of the date and circumstances the photographs were taken, and the clinician's interpretation, i.e. which digits/phalanges show colour change, the nature of the colour change and the demarcation. Notes should also record that the photographs were considered in the diagnosis and staging, and the influence of the photographs on the conclusions drawn and advice offered.

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8. METHODOLOGIES FOR CLINICAL EXAMINATION

Written by Prof J Belch

8.1. Blood Pressure

Step 1: Choose the right equipment

What you will need:

- A quality stethoscope
- An appropriately sized blood pressure cuff
- A blood pressure measurement instrument

Step 2: Prepare the subject

Make sure the subject is relaxed by allowing 5 minutes to relax before the first reading. The subject should sit upright with their upper arm positioned so it is level with their heart and feet flat on the floor.

Remove excess clothing that might interfere with the BP cuff or constrict blood flow in the arm. Be sure you and the subject refrain from talking during the reading.

Step 3: Choose the proper BP cuff size

Most measurement errors occur by not taking the time to choose the proper cuff size. Wrap the cuff around the subject's arm and use the lines marked on the cuff to determine if the subject's arm circumference falls within the acceptable range for that cuff. If it does not, choose the appropriate smaller or larger cuff.

Step 4: Place the BP cuff on the subject's arm

Palpate/locate the brachial artery and position the BP cuff so that the ARTERY marker points to the brachial artery. Wrap the BP cuff snugly around the arm.

UNLESS AN AUTOMATED BP MACHINE IS BEING USED FOLLOW THE INSTRUCTIONS BELOW:

Step 5: Position the stethoscope

On the same arm that you placed the BP cuff, palpate the arm at the antecubital fossa (crease of the arm) to locate the strongest pulse sounds and place the bell of the stethoscope over the brachial artery at this location.

Step 6: Inflate the BP cuff

Begin pumping the cuff bulb as you listen to the pulse sounds. When the BP cuff has inflated enough to stop blood flow you should hear no sounds through the stethoscope. The gauge should read 30 to 40 mmHg above the person's normal BP reading. If this value is unknown, you can inflate the cuff to 160 - 180 mmHg. (If pulse sounds are heard right away, inflate to a higher pressure.)

Step 7: Slowly deflate the BP cuff, begin deflation.

The AHA recommends that the pressure should fall at 2 - 3 mmHg per second, anything faster may likely result in an inaccurate measurement. *

Step 8: Listen for the Systolic Reading

The first occurrence of rhythmic sounds heard as blood begins to flow through the artery is the subject's systolic pressure. This may resemble a tapping noise at first.

Step 9: Listen for the Diastolic Reading

Continue to listen as the BP cuff pressure drops and the sounds fade. Note the gauge reading when the rhythmic sounds stop (which is known as the fifth Korotkov sound). This will be the diastolic reading.

For complete accuracy a mean of three readings can be employed.

IN ALL CASES:

Step 10: Repeat Procedure in Other Arm

It is important to measure BP in both arms. Use of two sphygmomanometers may be considered to measure the two arms simultaneously. A difference of 20 mm Hg or more between the two sides may indicate subclavian arterial obstruction.

8.2 Grip Strength

Background: This procedure is to be used for measuring handgrip strength. Grip strength has been shown in previous studies to be a predictor of current and future health.

Purpose: To ensure correct and uniform measurement of handgrip strength.

Scope: This procedure applies to any study requiring measurements of handgrip strength.

Responsibilities: It is the responsibility of the measurer to use this procedure when measuring handgrip strength. It is the responsibility of the principal investigator to ensure that staff members who are working on specific studies have adequate experience to do so.

Step 1: Choose the right equipment

There are a number of machines available to measure Grip Strength and choosing one which makes accurate and reproducible measures is key. This document has been prepared as a Standard Operating Procedure (SOP) for using the JAMAR hydraulic hand dynamometer to measure grip strength (see Figure 3).

The dynamometer has a dual scale readout which displays isometric grip force from 0-90 kg (0-200lb). The outer dial registers the result in kg and the inner dial registers the result in lb. It has a peak hold needle which automatically retains the highest reading until the device is reset. The handle easily adjusts to five grip positions from 35-87 mm (1½ - 3¼") in 13 mm (½") increments. Always use the wrist strap to prevent the dynamometer from falling on the floor if accidentally dropped.

The NIHR and some instrument manufacturers recommend that checks below are carried out on SCBR dynamometers quarterly, although if well cared for, the device should only need to be calibrated annually. A six- monthly calibration is recommended by the manufacturers if the device is subjected to vibrations on a frequent basis, e.g. carried around in a car.

If the instrument has been dropped or there is any reason to suspect that the calibration is erroneous, the instrument should be sent for servicing. Some will accept annual checks to ensure that the instruments are measuring accurately. These suggestions for the Jamar dynamometer are made by the manufacturer in the owner's manual (link).

The Jamar Hand Dynamometer calibration procedure is carried out off-site. The frequency of external calibrations will be specific to each study so make sure you are aware of when the external calibrations are due and ensure that, if required, there is another device available for use during the period of time when yours is offsite. See Appendix G for details of checking and maintaining the dynamometer.

Procedure

1. Document the serial number of the dynamometer you are using.
2. Wash your hands and explain the procedure to the participant.
3. Ensure that the dynamometer is cleaned before use. An appropriate single use wipe is sufficient unless there is reason to believe there has been gross contamination.
4. Ask the participant to remove their shoes and also any watches and/or bracelets.
5. Record the participant's hand dominance.
6. Demonstrate how to hold the dynamometer to the participant by testing it on yourself and explain how the dial registers the best result by squeezing as tightly as possible.
7. Sit them comfortably in a chair with a back support.
8. Use the same style of chair for every measurement.
9. Ask the participant to rest their forearms on the arms of the chair and keep their feet flat on the floor. You should ask the participant to roll their trousers/jeans up in order to ensure their feet are flat on the floor and do not rise from the floor when squeezing the dynamometer.
10. Their wrists should be just over the end of the chair's arm, thumb facing upwards.
11. Ask them to position their thumb round one side and their fingers around the other side of the handle. When they are holding the dynamometer in the correct position their fingers and thumb should be visible on the same side of the apparatus (figure 3).

Figure 3: hydraulic dynamometer

12. Check with them that the instrument feels comfortable in their hand. The position of the handle can be adjusted if necessary, for different sized hands. You will notice whether the handle needs altering based on the distance of the four fingers from the palm of the hand. If the fingernails are digging into the palm, it will be uncomfortable for the participant and means that the handle needs moving further away from the mechanism. If it looks as though the fingers are not close enough to the palm and it feels to the participant as though their hand may slip off the handle when squeezing, it suggests that the handle needs to be adjusted to bring it closer to the mechanism.

13. Inform them that it will feel as if there was no resistance.

14. Ensure the red needle is in the "0" position by turning the dial.

15. Start with the right hand and then repeat the measurement with the left hand.

16. The measurer should support the weight of the dynamometer by resting it on their palm while the subject holds the dynamometer, but they should not be restricting the movement of the device.

17. Encourage squeezing as long and as tightly as possible for the best result until the needle stops rising. Use a standard squeezing phrase "Squeeze......harder, harder...and stop squeezing"

18. When the needle stops rising read the measurement (in kg) from the dial and record the result to the nearest 1kg. The outside dial registers the result in kg and the inner dial in lb.

19. Disregard and repeat the test if the participant's arm rises above the arm of the chair, or if their feet lift off the floor during the measurement.

20. Record three measurements for each hand, alternating sides.

21. Thank the participant.

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8.3 Purdue Peg Board Test

Administration

Before administering the Purdue Pegboard Test, the test administrator is advised to carefully read this section of the manual. As with any standardised test, it is important to follow the directions very closely. The test must be administered to all applicants according to the standardised test procedure. If the test is not given identically, irrelevant factors may affect test scores. In order to reduce the variability among test administrator's, specific details regarding the arrangement of materials and the testing procedures are presented below.

Practice the administration of the Purdue Pegboard before conducting a test on a subject. The amount of practice needed in order to become comfortable with the testing process is dependent upon the test administrator's previous testing experience. The test administrator should practice the Purdue Pegboard until he or she is able to perform each of the tests at an average speed for demonstration purposes. Note: The test administrator will be demonstrating to the test subject what is expected of him or her before each test.

Test Batteries and Timing

The test administrator will compile 5 separate scores from the complete test procedure, one for each test battery:

1. Right Hand (30 seconds)
2. Left Hand (30 seconds)
3. Both Hands (30 seconds)
4. Right + Left + Both Hands (*Note: no. 4 is not an actual test; it is a mathematical sum calculation)*
5. Assembly (60 seconds)

The test batteries should be done in this consecutive order, unless the subject is left-handed, where test batteries 1 and 2 are reversed: Left Hand first and then Right Hand.

Three test trials are highly recommended: the more trials administered, the more test score reliability.

Note: The test is well suited for either group or individual testing.

Equipment Required

The following equipment and supplies are required to ensure that the Lafayette Instrument Purdue Pegboard Test is a consistent, standardised test:

1. Purdue Pegboard Test (Model #32020)
    a. Instruction manual
    b. 1 Test Board
    c. Pins, Collars, Washers
    d. Score Sheets
2. At least one testing table approximately 30 inches tall.

Note: The subject must be seated throughout the administration of the test.

3. Stopwatch or clock that reads in seconds.

Figure 4: Purdue Peg Board

Test procedures

General Instructions

The subject should be comfortably seated at the testing table directly in front of the Purdue Pegboard, which is placed on the table with the row of cups (under the nameplate) at the top of the board. The far right and far left cups should have 25 pins in each to equal a total of 50 pins. For right-handed subjects, the cup to the right of centre should have 40 washers. If the subject is left-handed, the collar and washer locations should be on the reverse of centre. The following directions are for single subject testing and should be appropriately modified for group testing.

When the subject(s) is seated and ready to begin, say:

“This is a test to see how quickly and accurately you can work with your hands. Before you begin each battery of the test, you will be told what to do and then you will have an opportunity to practice. Be sure you understand exactly what to do.”

Right Hand (30 seconds)

Begin by saying and demonstrating:

“Pick up one pin at a time with your right hand from the right-handed cup. Starting with the top hole, place each pin in the right-handed row. [*Leave the pin used for demonstration in the hole*.] Now you may insert a few pins for practice. If during the testing time you drop a pin, do not stop to pick it up. Simply continue by picking another pin out of the cup.”

Correct any errors made in placing the pins and answer any questions. When the subject has inserted three or four pins and appears to understand the operation, say:

“Stop. Now take out the practice pins and put them back into the righthanded cup.”

After the subject completes this task, say:

“When I say ‘Begin,’ place as many pins as possible in the right- handed row, starting with the top hole. Work as rapidly as you can until I say ‘Stop.’ Are you ready? Begin.”

Start timing when you say “Begin.” At the end of exactly 30 seconds, say: “Stop.”

Left Hand (30 seconds)

Begin by saying:

“Pick up one pin at a time with your left hand from the left- handed cup. Place each pin in the left-handed row, starting with the top hole. You may insert a few pins for practice.”

When the subject has inserted three or four pins and appears to understand the operation, say:

“Stop. Now take out the practice pins and put them back into the lefthanded cup.”

After the subject completes the task, say:

When I say ‘Begin,’ place as many pins as possible in the left- handed row, starting with the top hole. Work as rapidly as you can until I say ‘Stop.’ Are you ready? Begin.”

Start timing exactly when you say “Begin.” At the end of exactly 30 seconds, say: “Stop.”

Count the number of pins inserted and record the Left- hand score. This is the total number of pins the subject placed with the left hand. Leave the pins in the holes.

After the Right Hand and Left-Hand test batteries have been completed, the subject returns all pins to their proper cups.

Both Hands (30 seconds)

This test battery tests both hands working together. Begin by saying:

"For this part of the test, you will use both hands at the same time. Pick up a pin from the right-handed cup with your right hand, and at the same time pick up a pin from the left-handed cup with your left hand. Then place the pins down the rows. Begin with the top hole of both rows. [Demonstrate. Then replace the pins used for demonstration.] Now you may insert a few pins with both hands for practice."

After the subject has three of four pairs of practice pins correctly inserted, say:

"Stop. Take out the practice pins and put them back in their cups."

Then say:

"When I say 'Begin,' place as many pins as possible with both hands, starting with the top hole of both rows. Work as rapidly as you can, until I say 'Stop.' Are you ready? Begin."

Start timing when you say "Begin." At the end of exactly 30 seconds, say "Stop."

Count the number of pairs of pins inserted (not the total number of pins) and record the score. The subject then returns the pins to the proper cups.

Right + Left + Both (Sum of scores)

This score is not based on a separate test; it is obtained from combining the test scores of the previous three test batteries. Add the scores recorded for Right Hand, left Hand and Both Hands; this is the score that you record for R + L+ Both.

This score does not have to be recorded during the actual testing period. The Assembly test may begin immediately after both hands score is recorded.

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8.4 Monofilaments (Semmes- Weinstein or WEST)

This discriminative test is used to assess the threshold stimulus necessary for perception of light touch to deep pressure. The assessment requires the use of monofilaments that are available in either a 5- or 20-piece assessment kit.

Assessment technique

- Testing should be done in a quiet area with vision occluded.
- The subject's hand should be comfortable and rested on a table with palm uppermost to avoid moving the finger especially when using the larger filaments.
- Instruct the subject to respond when a stimulus is felt saying "Yes" or "Touch".
- When testing proceed from distal to proximal and from small to large monofilaments. It is our opinion that for routine Havs assessment it is only necessary to test pulp over dp. Avoid callus/ thick skin
- It is not necessary to test every area of the skin, checks may be done over areas innervated by different nerves.
- Press the filament at a 90-degree angle for 1.5 seconds against the skin until the filament bows and then remove. Gentle application for 1-2 seconds, bend of 3-5 mm
- Filaments 2.83 and 3.61 are applied three times in each spot. A single response indicates a positive result.
- For filaments 4.31, 4.56 and 6.65 only apply once.
- When the subject indicates a correct response record using the colour pencil that corresponds to the colour on the handle of the monofilament onto a hand diagram.
- The subject should only be asked when a stimulus is felt and not where they feel it.

8.5 Two-point discrimination

This test is used to evaluate the perception of either one or two points of touch and to assess the quality of fine discriminative sensation. It is assessed using a small tool with prongs at fixed spacings from 2mm to 15mm. It should only be used when the skin has sensory return of light touch.

Assessment technique

- Testing should be done in a quiet area with vision occluded.
- The subject's hand should be firmly supported in order to avoid unwanted movement of the fingers.
- Demonstrate to the subject on a normally innervated skin area initially.
- Starting on a 5mm distance between the two points.
- Randomly place either 1 or 2 points parallel to the long axis of the finger along each phalanx until the skin blanches. Start distally and work proximally.

- The subject is asked whether 1 or 2 points has been felt. This should be repeated 10 times in each area.
- If 7/10 responses are correctly identified, then the distance is scored.
- If the responses are inaccurate then the distance between the two end points is increased by increments of either 1, 2 or 5mm depending on the suspected level of dysfunction.
- Equal pressure most be applied between the two points simultaneously.
- Two-point discrimination can be assessed as a static or moving pressure.
- To assess moving pressure – randomly place either 1 or 2 points then maintain contact and move distally.

Table 2 – Filament size

Green	2.83	Normal
Blue	3.61	Diminished light touch
Purple	4.31	Diminished protective sensation
Red	4.56	Loss of protective sensation
Red lines	6.65	Deep pressure sensation only

RESULTS

Normal	<6mm
Fair	6-10mm
Poor	11-15mm
Protective	One point perceived
Anaesthetic	No points perceived

8.6 Moberg pick up test

The Moberg test can be used to assess functional sensational rather than threshold sensation. It is quick to perform and gives both the subject and therapist a clear demonstration of functional ability. It can only be used if a reasonable return of sensation has already occurred in the fingertips.

Test equipment

12 small metal objects that require precision grip including: wing nut, screw, key, large nut, large coin, small coin, safety pin, paper clip, square nut, hexagonal nut and a washer.

Assessment technique

- The objects should be placed alongside the container on the side being tested first.
- The subject is asked to pick up the objects one at a time from the tabletop and place them in the pot as quickly as possible. They should not slide the objects off the table.
- The time and manner of prehension is recorded. Discontinue if the test takes longer than 5 minutes making a note of how many objects have been correctly placed.
- Repeat the test with the opposite hand and then repeat this sequence 3 times on each hand.
- The same task is then repeated blindfolded for each hand 3 times.

- The vision occluded section should not be attempted if the sensory deficit is too severe.
- The subjects can also be timed for object recognition. Each object is randomly selected and placed in the subjects three-point grip on the affected side and then asked to identify the item. Repeat this twice until all the objects are identified but allow no longer than 30 seconds per object.

Results

A comparison between the two hands can be made showing the results as a percentage to demonstrate change with further assessments. The uninjured hand is taken as the norm (100%) therefore if the injured hand is slower the score will be greater than 100%.

8.7. Shape/Texture identification (STI) test

This test is a quantitative test used for assessing tactile gnosis. The test is performed according to a standardised procedure and is based on active touch. The test is composed of four separate discs each containing three shapes (Cube, cylinder and hexagon) of different diameters (15mm, 8mm or 5mm). The test also presents raised dots in groups of 1, 2 or 3, spaced differently on each disc.

Assessment technique

Seat the subject at a table with the template containing the samples of the shapes and textures in front of them.

- Ask the subject to identify the shapes and textures presented, first with the uninjured hand.
- The test is performed using the pulp of either the index or little finger only requiring a minimal motor element.
- The largest shapes should be used initially and the choice of 3 shapes presented randomly by spinning the disc.
- Repeat with the medium and finally the small shapes, offering each shape only once.
- This should then be repeated with the injured hand using either the index finger for median nerve injuries or little finger for ulnar nerve injuries.
- The disc with the largest spacing of raised dots should then be used and the number of dots should be presented randomly for identification with the uninjured hand.
- Repeat with the medium and finally small spacing of raised dots offering each texture only once and then repeat on the injured hand.

Results

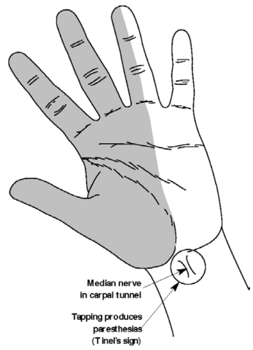
If all 3 shapes and textures on the disc are correctly identified the subject scores a point for each giving a potential range from 0-6 on each hand. The norm is taken to be 6, based on testing of 60 control subjects (Rosen and Lundborg, 1998). An increasing score will reflect recovery.

8.8. Tinel's sign

Elicitation:

Tap over the median nerve as it passes through the carpal tunnel in the wrist.

Positive response is usually a sensation of tingling in the distribution of the median nerve over the hand.

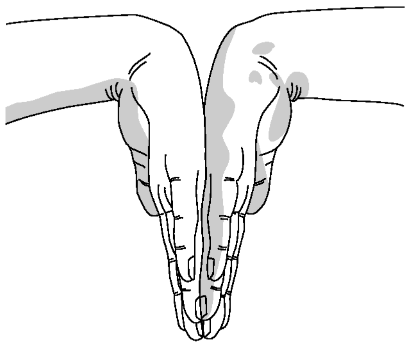


8.9. Phalen's manoeuvre

Elicitation:

Allow wrists to fall freely into maximum flexion and maintain the position for 60 seconds or more.

Positive response is usually sensation of tingling in the distribution of the median nerve over the hand.



8.10 Allen's test

Anatomical basis

The hand is normally supplied by blood from both the ulnar and radial arteries. The arteries join in the hand. Thus, if the blood supply from one of the arteries is cut off, the other artery can supply adequate blood to the hand. A minority of people lack this dual blood supply.

i) Original Test

The original test proposed by Allen is performed as follows:

- Step 1 - The subject is asked to clench both fists tightly for 1 minute at the same time.
- Step 2 - Pressure is applied over both radial arteries simultaneously so as to occlude them.
- Step 3 - The subject then opens the fingers of both hands rapidly and the examiner compares the colour of both. The initial pallor should be replaced quickly by rubor.
- Step 4 - The test may be repeated, this time occluding the ulnar arteries.

Allen's test looks for abnormal circulation. If colour returns quickly as described above, Allen's test is considered to demonstrate normal circulation. If the pallor persists for some time after the subject opens their fingers, this suggests a degree of occlusion of the uncompressed artery.

ii) Modified Test

- Step 1 - In the modified Allen test, one hand is examined at a time.
- Step 2 - The hand is elevated, and the subject is asked to clench their first for about 30 seconds.
- Step 3 - Firm pressure is applied over the ulnar and the radial arteries so as to occlude both of them.
- Step 4 - Still elevated, the hand is then opened. It should appear blanched (pallor may be observed at the fingernails).
- Step 5 - Ulnar pressure is released while radial pressure in maintained, and the colour should return within 5 to 15 seconds.

If colour returns as described, Allen's test is considered to be normal. If colour fails to return, the test is considered abnormal and it suggests that the ulnar artery supply to the hand is not sufficient. This indicates that it may not be safe to cannulate or needle the radial artery.

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9. THE STAGING (GRADING) OF HAND ARM VIBRATION SYNDROME

Written by Dr Roger Cooke

Background

Grading or staging of HAVS is intended to

- give an indication of the severity of the condition
- assist in monitoring changes in the condition from one assessment to the next,

and

- provide a clinical basis for managing the condition.

The current standard for grading the severity of HAVS is the Stockholm Workshop Scale (SWS) for vascular and sensorineural deficit[1,2], with the modifications proposed by McGeogh, Lawson et al[3]. Use of this may be facilitated by use of the Griffin numerical scale for the extent of vascular symptoms (blanching). The pros and cons of the SWS were reviewed by Lawson[4].

The Stockholm Workshop Scale

The pioneering work by Taylor and Pelmear led to the development of the Taylor-Pelmear scale in 1968, which was published in 1975[5]. This is now of historical interest, although it is still encountered on occasion, for example in medico-legal reports. It is not used for health surveillance purposes.

The Stockholm Workshop Scale was largely based on Taylor-Pelmear but split the grading for vascular and sensorineural symptoms. For each of those components a grade of "0" indicates vibration exposure but no relevant symptoms. Any relevant symptoms are then graded into 1, 2 or 3 to reflect the severity of the condition. It is generally agreed that severe Raynaud's phenomenon with trophic skin changes, previously known as stage '4v' in the Stockholm Workshop Scale, is more likely to represent an underlying medical condition than be due to the effects of vibration, so employees with this degree of disease should be referred for further clinical assessment via their GP.

The two components should be assessed separately, with the vascular grading primarily reflecting the extent of blanching. Use of the Griffin scale[6] (see below - also sometimes referred to as the Cornish-Rigby scale[7]) may assist in this process. While frequency of attacks is included within the definitions of the vascular grades, care should be taken to ensure that this does not reflect changes in the pattern of cold exposure. The extent of blanching overrides frequency of attacks when assessing severity. There is likely to be benefit in reviewing the pattern of attacks 12 months after initial diagnosis in order to be able to assess the full seasonal variation, and therefore a range of temperature exposures.

Clinical judgement will be required where there is divergence between Griffin score and the Stockholm description. For example, if one finger is affected over two phalanges that would be stage 1v based on a Griffin score of 3, but because it involves distal and middle phalanges a grade of 2v would be applied using the Stockholm descriptors. In this circumstance, if differing interpretations of the grading systems lead to a change of grading in subsequent assessments, it is essential that all concerned appreciate that this does not reflect a change in the severity of the condition.

The vascular grades are as follows:

Stage 1v: Attacks affecting only the tips of the distal phalanges of one or more fingers - usually with a Griffin blanching score of 1-4.

Stage 2v (early): Occasional attacks (i.e. three or less per week) affecting the distal and middle (and occasionally proximal) of one or more fingers – usually with a Griffin score of 5-9.

Stage 2v (late): Frequent attacks (i.e. more than three per week) of whiteness affecting the distal and middle (rarely also proximal) phalanges of one or more fingers - usually with a Griffin blanching score of 10-16.

Stage 3v: Frequent attacks of whiteness affecting all the phalanges of most of the fingers all year - usually with a Griffin blanching score of 18 or more.

The sensorineural grades are as follows:

Stage 1sn: Intermittent tingling and/or numbness, without any abnormality on sensory testing. Care should be taken to distinguish this from the normal response to vibration exposure. Persistence of the tingling and/or numbness for more than 20 minutes after cessation of tool use is usually taken as indicating progression beyond normality, although that may be dependent on the duration and level of exposure immediately preceding the symptoms.

Stage 2sn: Intermittent tingling and/or numbness with reduced perception. Intermittent is regarded as lasting less than two hours, and this should be accompanied by examination evidence of impaired sensation - usually light touch and/or pin prick sensation.

Stage 3sn: Persistent tingling and/or numbness with reduced sensory perception (as for stage 2sn) and reduced manipulative dexterity in the warm. The original Stockholm Workshop scale refers to impairment of tactile discrimination in the definition of stage 3sn, but the later modified scale quoted by HSE no longer includes that.

Careful relevant neurological examination is essential in determining the grading of the sensorineural component. It is important to remember that numbness is a symptom – that is something of which the patient complains – as opposed to a sign, which is a finding on clinical examination. For these purposes, reduced sensory perception, reduced tactile discrimination, and reduced manipulative dexterity are signs; given that numbness is the symptom of reduced sensory perception, the definition of stage 2sn would otherwise be meaningless repetition.

For sensorineural grading, the first Stockholm Workshop propounded an assessment process of testing light touch, pinprick, and temperature – each of which scored 1 if abnormal – and two-point discrimination, which scored 2. Adding those scores together allowed the following grading:

- score of 0 or 1 = 1sn
- score of 2 or 3 = 2sn
- score of 4 or 5 = 3sn

It is conventional to record the score for each hand separately; hence, for example, a scoring of 'L2v(3) 2sn; R1v(2) 2sn' indicates stage 2 vascular disease affecting three fingers of the left hand, with stage 2 sensorineural disease for the left hand, and stage 1 vascular disease affecting two fingers of the right hand which also has stage 2 sensorineural disease. In practical terms it is useful to record extent of colour change on a diagram of the hand. Any available digital photography should be recorded. While this may not necessarily capture all affected fingers during a single attack, it may be strongly supportive that true vasospasm is being described.

In the UK it has become conventional to divide stage 2 vascular or sensorineural into 'early' or 'late', that distinction being used particularly to monitor progression towards more incapacitating effects of vibration.

Cold sensitivity or intolerance should also be recorded. While this remains a matter of debate, the presence of cold sensitivity does not currently affect either the vascular or sensorineural grading[8].

The Griffin Scale

The Griffin scale[5] may be useful in describing the severity of the vascular component and is based on a score calculated from which phalanges of each digit are affected. The scores are shown in the attached diagram, and the individual scores for each digit are then added to give a total score out of a potential maximum of 33.

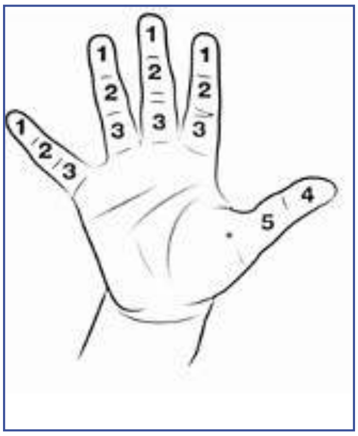

Diagram showing scores attributed to each phalanx in the Griffin scale

Hence if the whole finger is affected by blanching a score of 6 would be applied. It is likely to be helpful if a diagram is included in the employee's clinical record so that the distribution as well as the extent of blanching is recorded.

A score of 17 on the Griffin scale is possible but unlikely, requiring the involvement of the full extent of the thumb (score 9), with a score of 8 for the fingers. It has been suggested that Raynaud's phenomenon of the thumb may be an indication of underlying connective tissue disease[9]. On that basis, specialist referral should be considered where there is involvement of the thumb without a clear history of exposure of that thumb to vibration.

The International Consensus Scale

A recently proposed scale was intended to replace the Stockholm Workshop Scale[10] but has not been adopted by HSE in their 2019 Guidance L140. This scale advocated a number of changes in approach, including:

- Loss of the division of stage 2 into early and late
- Use of two or more validated tests to diagnose stage 2sn - in practical terms meaning use of standardised testing
- Referral to a specialist centre for employees with significant deterioration in bend force threshold on monofilament testing
- Stage 3v to include those with a Griffin score of greater than 12.

At the time of writing, this scale has not been recommended by HSE, and it is the view of the SOM HAVS Special Interest Group that the Stockholm and Griffin scales should remain as the standard classification systems for grading the severity of HAVS.

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10. CARPAL TUNNEL SYNDROME AND WORK WITH VIBRATING TOOLS

Written by Dr Roger Cooke

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.

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[1].

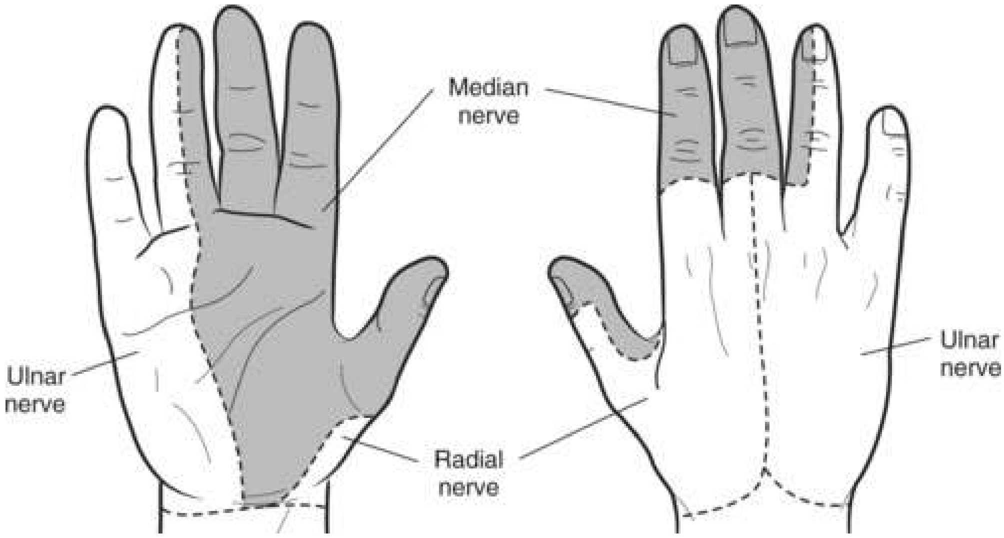
Presentation

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[2] 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[3].

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.



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 following page. 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%[4], 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. (See appendix K for further information on Nerve conduction studies).

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.

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?

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.

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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

Brent GJ The Value added by Electrodiagnostic Testing in the Diagnosis of Carpal Tunnel Syndrome Bone Joint Surg (Amer) 2008; 90: 2587-2593

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 with nerve entrapment in vibration-exposed workers[7].

Causes of CTS

Constitutional risk factors include diabetes[8] 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[9].

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[10, 11, 12]. Systematic reviews have also shown strong to moderate associations (OR 2.5—4. 8)[13, 14]. 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[15]. However, Lawson has noted that an absence of evidence does not necessarily mean there is no dose-response relationship – only that those studies have so far failed to identify one[16]. 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[17], it is unclear whether this definition can be applied to RIDDOR.

Differential diagnosis of CTS

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[18, 19]. 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[20].

Sensorineural hand arm vibration syndrome

The sensory symptoms presenting in CTS can be confused with sensory HAVS[21]. 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[22]. 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[23].
- 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[24].
- 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)[25].
- 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[26].

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[27]. Testing these small fibres is unlikely to have any practical utility in detecting CTS[28]. 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[29]. It remains essential that the results of the tests are considered in the context of those presenting symptoms and associated clinical signs.

Treatment of CTS

Treatment of CTS may include the following:

1. Avoidance of identifiable triggers.
2. 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.
3. Steroid injection – likely to provide temporary relief only and may be useful diagnostically.
4. Surgery – either open or keyhole, with no evidence of one being more effective than the other.

Workplace management of CTS

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.

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11. DUPUYTREN'S DISEASE

Written by Dr Ian Lawson

Key messages

1. Dupuytren's disease (DD) is one of the commonest hand conditions.
2. With the inclusion of Dupuytren's contracture to the list of prescribed diseases (PD A11) from work with hand-held vibrating tools, occupational health practitioners will need to be more aware of the natural history and risk factors associated with the condition to address questions regarding work causation.
3. Health surveillance of workers exposed to hand transmitted vibration from hand-held vibrating tools should ask questions about Dupuytren's disease and diathesis. Tier 3 and tier 4 assessments should include palmar examination for the presence of nodules, cords, contractures and consider differential diagnoses.
4. Not all cases of Dupuytren's disease progress to contracture, nor is it clear whether traditional risk factors, now including vibration exposure, affect this progression once initiated.
5. Fitness for work advice should be by individual case consideration and primarily based on functional limitations and task specific safety issues.

Background

Dupuytren's disease (DD) is a common fibro-proliferative connective tissue disorder of the palmo-digital fascia (aponeurosis) of the hand resulting in the formation of nodules and cords, which in turn can result in irreversible flexion contracture of the digits.[1,2] A systematic review reported DD is commoner in men with prevalence rising with age; median prevalence ranging from 12% at 55, 21% at 65 and 29% at 75 years of age.[3] A systematic review and meta-analysis found a consistent association between Dupuytren's disease and diabetes, liver disease, and epilepsy.[4] There is also a strong genetic component leading to DD at a younger age.[5]

Presentation

The early stages of DD are characterised by thickening, pitting and nodule formation of the palmo-digital fascia between the attached skin and deeper fascia. This is often described by the individual as puckering of the skin.

A nodule can progress to form a cord which over the course of months to years can contract pulling the finger down into the palm. The resulting contracture depends on which part of the palmo-digital and digital fascia undergoes fibrosis (Figure 1 below).

A pretendinous cord contracture leads to fixed contracture of metacarpophalangeal joints (MCPJ); a central cord contracture to fixed flexion contracture of the proximal interphalangeal joints (PIPJ); a lateral cord contracture to fixed flexion contracture of the PIPJ and distal interphalangeal (DIPJ) or combinations of these.[6]

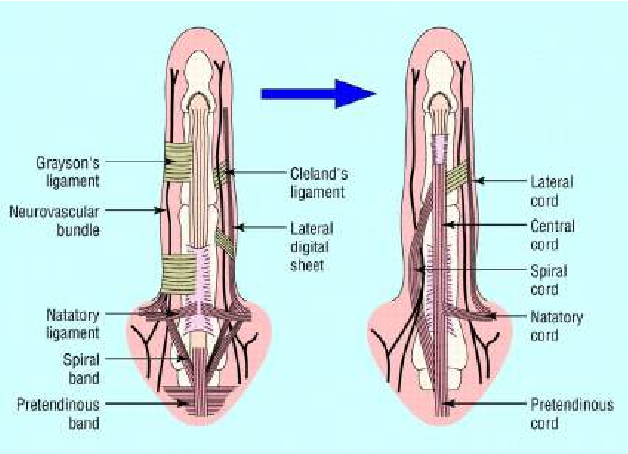


Figure 1. Normal fascia and diseased fascial cords, after Townley et al[6]

The little and ring fingers are the most commonly affected and very occasionally the thumb. The condition is frequently bilateral with MCPJ and PIPJ both contributing to the overall contracture. It should be however stressed that isolated contracture just affecting the MCPJ is common.

Those with a family history of Dupuytren diathesis often have bilateral disease and develop ectopic Dupuytren tissue deposits at a younger age and in other areas such as dorsal surface of PIPJ (Garrods knuckle pads), plantar fascia (Ledderhose disease) or penis (Peyronie's disease).

The majority of cases do not progress to contracture, developing nodules only. In a study of 306 hand clinic diagnosed cases of palmar fibromatosis only 8% had contractures.[7] A prospective study of 398 participants followed for seven years (n=763 in original study) found a greater degree of progression in those with a higher initial stage of disease (21.5%).[8]

The question of progression and individual management is discussed below.

Diagnosis

The diagnosis is made by clinical examination based on observation of contractures or palpation of thickening, nodules or cords. Tendons and skeletal structures are unaffected. Once encountered it is unlikely to be confused with other conditions. History of possible Dupuytren's diathesis should be excluded. In addition, the following conditions albeit uncommon, apart from trigger finger, should be considered in any atypical presentation of palmar nodules or finger contractions in the differential diagnoses:

Volkmann's contracture

Whilst this rare eponymous condition can cause permanent deformity of the fingers it is usually accompanied by deformity of the hand and wrist. It results from ischaemia in the forearm, sometimes the result of compartment syndrome but more often following a history of significant injury and supracondylar fracture of the humerus. The resulting long term damage to nerve and muscle tissue results in the later presentation of contractures. It presents with a 'claw-like' appearance from fixed flexion in the flexor tendons of the forearm.

Keloids

Keloid is an uncommon fibroproliferative disorder characterised by the deposition of collagen in a wound.[9] Keloids are abnormal scar tissue formations following on from a wound which presents as painful, pruritic nodules. Unlike hypertrophic scars they extend beyond the border of the wound. They can occasionally form spontaneously particularly if there is a family history of keloids. They are diagnosed clinically presenting as enlarged skin-, red- or dark-coloured raised scars that feel firm and smooth to touch. They usually appear several weeks following a skin wound and may continue to grow for several months or even years. It is extremely rare for a keloid to occur in the palms.[10,11]

Trigger finger (stenosing flexor tenosynovitis)

Trigger finger is a common condition particularly in 50-60 year old women with a reported population prevalence of approximately two percent.[12] It is caused by either thickening of the tendon or tendon sheath such that the tendon is restricted from gliding, resulting in it catching at the palmar edge of the annular A1 pulley at the MCPJ. It can result in difficulty flexing or extending the finger sometimes releasing with a 'triggering' effect.

Several fingers can be affected, sometimes in both hands but most commonly in the ring finger. It is commoner in diabetes, rheumatoid arthritis and carpal tunnel syndrome. It is unlikely to lead to a fixed flexion deformity although later untreated stages can present with fixed PIPJ. A palpable snapping along with tenderness over the A1 pulley may be found on examination.

Ganglions

Ganglions are harmless synovial sheath cysts that usually occur on the dorsal surface of the wrist. Occasionally they occur on palmar aspect of wrist or flexor tendon sheaths. The latter tend to occur in young adults presenting with a pea sized lump at the base of a finger.

Epidermoid cysts

An epidermoid cyst results from an occluded pilosebaceous gland. They generally present in young to middle aged adults and are commoner in men.

On glabrous skin (hairless) such as the palm of the hand an epidermoid cyst may result from traumatic 'implantation' of epidermal cells into the dermis forming an epithelium-lined sac when it may be known as an "implantation dermoid". They present as a nodule or papule 1-3 cm in size attached to the surface skin along with a central punctum.

These should not be confused with dermoid cysts which arise from foetal developmental germ cells that form into a cyst. These usually present at birth or early childhood as solitary lumps between 0.5-6 cm and can present on the palm or finger.

Investigations are usually unnecessary unless there is an atypical presentation such as concomitant skin ulcers. This may include ultrasound, magnetic resonance imaging or histology to exclude rare spindle cell sarcoma, synovial sarcoma, malignant peripheral nerve sheath tumour (MPNST), or epithelioid sarcoma.[13]

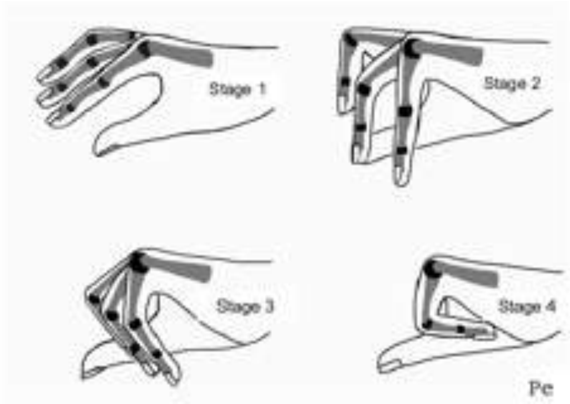
Staging and severity

The Hueston table top test was developed to assist in determining which patients were suitable to proceed to surgery. It is a simple way to determine the presence of a fixed flexion contracture.[14] The palmar surface of the hand is placed on a flat surface such as a table top. If it is not possible to place the palm flat to the surface without a gap remaining the test is deemed positive.

Another measure, incorporating the degrees of total flexion contracture can be assessed using a goniometer. Using this method, Tubiana developed a scale to stage the condition into four stages.[15]
The angle made by the dorsum of the hand with the dorsal surface of the middle phalanx of the affected finger is the measured angle for total flexion deformity (TFD):

Tubiana Stage	*Deformity*
0	No lesion
N	Palmar nodule without presence of contracture
1	TFD between 0° and 45°
2	TFD between 45° and 90°
3	TFD between 90° and 135°
4	TFD greater than 135°

Figure 2: Tubiana stages
(Illustration courtesy of Penny Burton)



The severity of contracture and which fingers are affected will determine any functional impairments often associated with a reduced grip. The effect on a variety of normal daily activities as a result of extension deficit may include simply placing hands in pockets, problems putting on gloves or shaking hands.

Pathology

The nodules have been found to consist of myofibroblasts that have the characteristics of both smooth muscle cells and fibroblasts which probably accounts for the contractile nature of Dupuytren's.[16] What causes the fibroblast to proliferate into a myofibroblast is not known but putative mechanisms include micro-vascular ischaemia, inflammatory processes or free radical formation.[17]

It has been suggested that an 'external' or 'internal' stimulus activates macrophages or platelets to produce fibrogenic cytokines such as transforming growth factor, TGF-β leading to the deposition of collagen fibres.[18] The nature of these 'external' and 'internal' stimuli has been informed by prevalence studies, although sometimes conflicting as alcohol, smoking, trauma, diabetes, epilepsy, and genetic predisposition.[3]

A systematic review of non-genetic risks found a 'strong association between Dupuytren's disease and advanced age, male sex, family history of Dupuytren's disease, diabetes mellitus, heavy alcohol drinking, cigarette smoking, and manual work exposure.' This study also found a dose response for heavy alcohol drinking, smoking and manual work.[19]

Dupuytren's Contracture and work with hand-held vibrating tools

Dupuytren's contracture as a result of traumatic injury or cumulative trauma arose out of an original case report in a coachman described by Dupuytren in 1831.[1] However as to whether manual work itself is a cause of DD is still considered to be a contentious issue. As with carpal tunnel syndrome, separating out ergonomic risk from hand transmitted vibration risk is not necessarily reported in studies.[20] Whilst this ergonomic aspect is not the subject of this review, suffice to say that heavy manual work without significant vibration exposure has been reported to be associated with Dupuytren's disease.[21]

A review of the evidence by Liss and Stock in 1996 reported increased odds ratios (OR) in three statistically significant studies.[22] These included Cocco et al reported an OR of 2.3 (CI 1.5- 4.4); Thomas and Clarke an OR of 2.1 (CI 1.1-3.9); and Bovenzi et al an OR of 2.6 (CI 1.2-5.5).[23, 24, 25]

Bar Bovenzi these studies were of relatively small sample size showing minimal evidence for a dose response relationship. Despite this, Liss and Stock concluded that there was enough support for a causal association between vibration exposure and Dupuytren's contracture. Thomas and Clarke[24] suggested a possible microvascular pathophysiological process having found a statistical association between vibration white finger (VWF) and Dupuytren's contracture.

A large cohort of 212 civil servants diagnosed with palmar fascia thickening with or without contracture found a higher prevalence in those using vibrating tools (adjusted for age, family history, diabetes, epilepsy, hand trauma and alcohol consumption).[26]

Some research has produced contradictory findings. A review of over 97,000 United Kingdom miners seeking compensation for HAVS found age to be the prime determinant regarding prevalence of Dupuytren's disease (prevalence in 35-39 year age group was 1.7% rising to 19.6% in 80-84 year group).[27] Although this compensation scheme did not award benefit for DD, reducing possible bias in presentation, the authors acknowledged limitations in controls and in exposure assessment necessary to define a dose response relationship.

Descatha et al carried out a meta-analysis attempting to address the conflicting findings from previous studies.[28] Using high quality methodological criteria (HQMC) that included pooled vibration exposure data (MOOSE and PRISMA checklists) they found pooled meta-OR of 2.88 (CI 1.36-6.07) and 2.14 (CI 1.59-2.88) for those studies that met the high quality methodological criteria.

A cross-sectional analysis of data previously sourced by postal survey requesting information on the previous week's sources of vibration exposure and presence of flexion contracture of ring or little fingers was analysed by Palmer et al.[29] Contracture was reported in 72 (1.4%) of male respondents (n= 4969). In men who reported vibration exposure (2287) the prevalence ratios (PR) showed a 1.5 fold increase and in those with estimated exposures above 2.8ms-2 there was an adjusted PR of 2.85 (CI 1.37-5.97; after adjustment for age, social class, occupational manual activities). Their conclusion was that the risks of Dupuytren's contracture was more than doubled in men with high levels of vibration exposure.

A recent updated meta-analysis on vibration exposure has added support to the conclusion that vibration is an independent risk factor for the development of DD with age and environmental factors having no effect on DD prevalence.[30]

Another recent retrospective case control study of males with 13% prevalence of DD (n = 515) divided into those exposed to hand transmitted vibration (HTV=193), heavy manual work (HMW=107) and controls (215) found significant associations between DD and HTV with an OR 4.59 (95% CI 2.05–10.32) and HMW an OR 3.10 (95% CI 1.21–7.91) with an increased risk after 15 years of exposure.[31]

Based on this epidemiological evidence, health surveillance of workers exposed to hand transmitted vibration from hand-held vibrating tools should ask questions about Dupuytren's disease and diathesis including palmar examination for the presence of nodules, cords, contractures along with consideration of a differential diagnosis.

Treatment

The majority of cases of Dupuytren's do not require treatment and should only be considered in cases with functional impairment. Some surgeons use the simple table top test. However, the British Society for Surgery of the Hand (BSSH) proposed a classification system of mild, moderate and severe contracture to assist decisions on intervention:

1. ***Mild:*** no functional problems, MCPJ contracture of less than 30° but no PIPJ contracture.
2. ***Moderate:*** functional problems, MCPJ contracture of 30° to 60°, PIPJ contracture of less than 30°, or first web contracture.
3. ***Severe:*** severe contracture of both MCPJ contracture greater than 60° and PIPJ contracture greater than 30°.

Based on this scale the mainstay of treatment is surgical intervention for MCPJ > 30 degrees or any degree of PIPJ contracture. Fasciectomy and dermofaciectomy are the main surgical interventions for moderate to severe disease. Percutaneous needle fasciotomy can be used for MCPJ involvement. However, recurrence is common particularly in those with Dupuytren's diathesis.

It should also be recognised that surgical intervention is not without risks. A study by Asler et al found re-operation rates of 33.7% for percutaneous needle fasciotomy, 19.5% for limited fasciectomy, and 18.2% for dermofasciectomy with re-operation for the latter carrying a high risk of amputation.32 Non-surgical alternatives to surgery, particularly injection with collagenase, have been compared with surgical intervention. A questionnaire study by Altziebler found lower complication rates, quicker return to work and higher satisfaction values.[33]

A systematic review on collagenase treatment, whilst indicating it was significantly better than placebo, found there was no evidence that it was clinically better or worse than surgical treatments.[34]

A determination from the National Institute for Health and Care Excellence (NICE Technology appraisal guidance [TA459]) in 2017 was that collagenase clostridium histolyticum (Xiapex) should only be used for research purposes in the UK. The Dupuytren's Interventions Surgery vs. Collagenase (DISC) Trial is still ongoing (https://www.bssh.ac.uk/professionals/disc_trial.aspx).

Return to work after surgery will depend on nature of work ranging from one week for sedentary roles to up to six-10 weeks for heavy manual work.[35]

An employee leaflet on Dupuytren's and surgical treatment was prepared by BSSH in 2016: https://www.bssh.ac.uk/_userfiles/pages/files/Patients/ Conditions/Elective/dupuytrens_disease_leaflet_2016.pdf

Details of other classification scales

'Notes on Dupuytren Measurement systems, Charles Eaton MD Dupuytren Research Group Jan 2018': https://dupuytrens.org/wp-content/uploads/2018/02/Notes-on-Dupuytren-Measurement-systems.pdf

Workplace management

The Industrial Injuries Advisory Council (IIAC) recommended inclusion of Dupuytren's contracture to the list of prescribed industrial diseases in 2014 (PD A15) having reviewed the evidence on exposure to hand-held vibrating tools and concluded that there was more than doubling of relative risk. Their recommendation specified the disease as fixed flexion deformity of one or more digits and included exposure criteria of work with vibrating tools for 'periods in aggregate of at least ten years...the use of tools amounts to at least two hours per day for three or more days per week...'[36]

This pragmatic threshold of exposure was based on the evidence of exposure bands in several studies (most listed in section 8). However, this does not necessarily align with a linear dose response relationship. Assessment for PD A15 Dupuytren's (PD A15) are likely to increase with a concurrent increase in employers liability claims over coming years. As yet Dupuytren's disease is not RIDDOR reportable. This, in turn, will focus employers on risk reduction and occupational health practitioners on providing advice regarding ongoing vibration exposure. Unlike HAVS and CTS there are few interventional studies on reversibility on cessation of exposure or return to work with vibrating tools after treatment. Stirling et al studied the impact of HTV exposure on the outcomes of surgery (n= 425 hands, 111 HTV exposure) using a QuickDASH questionnaire and found that whilst HAV exposure influenced pre- and post-operative function in HTV exposed there was no effect on overall satisfaction or return to work following surgery.37 Until such evidence is available advice on fitness for work with vibrating tools should be based on function and safety. As with hand transmitted vibration per se management advice should be to reduce vibration exposure to as low as reasonably practicable (ALARP).

In contrast to earlier studies a recent five year prospective cohort study (n=258) suggested that DD is progressive, with respect to disease extent and contracture severity mostly on the little finger side of the hand: i.e. yearly increase of in total passive extension deficit was 1.75 degrees (95% CI, 0.30 to 3.20 degrees) to 6.25 degrees (95% CI, 2.81 to 9.69 degrees).38

Although no progression or regression was found in 24% of dominant and 31% of non-dominant hands, none of the recognised risk or diathesis factors were associated with progression. These background levels of progression irrespective of risk make it problematic for occupational health practitioners to advise on continuing vibration exposure. It is conjectural, but possible that once the contractual phase has begun the initiating risks including vibration have little impact on progression.

General points on case management

1. Nodules can be painful but most functional issues result from lack of full finger extension and weakened grip strength.
2. Periodic observation every six to 12 months to determine the onset of contracture and the need for referral. A goniometer is an objective means of monitoring degrees of flexion contracture.
3. Advise the employee to consider alternative work only if there are functional or safety issues with work tasks.
4. Advise the employee regarding return to work after surgery that there is no current evidence to suggest a recurrence of symptoms is any more likely after returning to work with vibrating tools. The caveat is that recurrence of symptoms is common after surgery or collagenase injection.
5. Each case should be treated on an individual basis to determine the perception of risk which may have an impact on continuing exposure and successful return to work after surgery.
6. Advise the employee that Dupuytren's is a prescribed disease and they may be eligible to a disability assessment (https://www.gov.uk/guidance/claim-industrial-injuries-disablement-benefit-for- dupuytrens-contracture)

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12. OTHER VIBRATION-RELATED CONDITIONS

Written by Nikla Rai, Specialist Practitioner in OH (September 2018)

Consideration of HAVS exposure should be considered if the following medical conditions are disclosed at Tier 1 (Base Line) Medical Assessment, or subsequently:

Primary Raynaud's Phenomenon

Screening for family history of Raynaud's phenomenon should be included at Tier 1 as well as looking for any evidence of the presence of Raynaud's phenomenon prior to vibration exposure, where possible. The reason for this is because some workers often begin to work with vibrating tools in their late teens and early 20's before the symptoms of primary Raynaud's phenomenon are obvious. Omitting this baseline screening could potentially blur identification of symptoms at a later stage making it difficult to differentiate the vascular component of HAVS from primary Raynaud's phenomenon, especially if the symptoms begin within a few years of starting work. Primary Raynaud's phenomenon is typically in a younger age group, bilateral, symmetrical and may be associated with other vasospastic phenomena such as migraine.

Ageing and other conditions

The effects of ageing on skin blood flow should be assessed independently from those which may arise from HAVS. Other conditions which may affect blood flow in the hands, or cause Raynaud's phenomenon, include the following:

Vasospastic conditions (connective and mixed connective tissue disorders)	Occlusive conditions
• dermatomyositis • hypothyroidism • systemic lupus erythematosus • systemic sclerosis (limited & diffuse) formerly known as CREST	• atherosclerosis • cervical rib • cold haemagglutinins. • hyperfibrinogenaemia. • leukaemia. • polyarteritis nodosa. • thoracic outlet syndrome. • polycythaemia rubra vera. • thrombo-embolic disease • vasculitis.

Hypothenar and Thenar Hammer Syndromes

This condition is caused from a deficiency of the blood flow within the hand. Hypothenar hammer syndrome is caused by trauma to the hand or caused by reoccurring compression, squeezing, or hammering of the hand. This condition is not to be confused with a HAVS related problem. Hypothenar hammer syndrome affects the distal parts of the ulnar artery supplying the hand, and thenar hammer syndrome affects the distal radial artery.

Guyon Tunnel Syndrome

Also known as Ulnar Tunnel Syndrome is a compression of the ulnar nerve in Guyon's canal. It is caused by repeated and prolonged pressure applied to the base of the palm resulting in symptoms in the 4th/5th digits and ulnar side of the palm (depending on the level of compression).

Neuropathy

The neurological components of HAVS should be established independently from the following;

- alcoholic peripheral neuropathy
- cervical spondylosis
- diabetic peripheral neuropathy
- hemiplegia
- multiple sclerosis
- neurofibromatosis
- poliomyelitis
- spinal cord compression
- syringomyelia

Occupational neurotoxins should be considered, including:

- Acrylamide
- Antimony
- Arsenic
- Carbon disulphide
- Diethyl thiocarbamate
- Lead (inorganic)
- Mercury compounds
- Methylbutyl ketone
- n-hexane
- Organophosphates
- Thallium
- TOCP.

The effects of medication should also be excluded. Examples of medications that may be associated with neuropathy are:

- Chloramphenicol
- Nitrofurantoin
- Cyclosporine
- Perhexiline
- Ethambutol
- Phenytoin
- Gold
- Polymyxin
- Indomethacin, statins
- Isoniazid
- Streptomycin
- Metronidazole
- Vincristine.

Hearing loss

It is known that high frequency hearing loss occurs more commonly in those exposed to hand transmitted vibration than those with no such exposure but similar levels of noise exposure. However, given the possible noise exposure of those working with vibratory tools, the presence of deafness should not be used to assist in the diagnosis of HAVS.

13. HAND-TRANSMITTED VIBRATION AND IMPACT FORCES

Written by Dr Roger Cooke, February 2023

Key messages

1. There is a statutory duty under the Control of Vibration at Work regulations 2005 to assess health risks arising from repeated shocks
2. There may be technical difficulties measuring vibration levels associated with repeated impact tools.
3. The health effects of exposure to repeated impact vibration are not clearly defined.
4. There is no defined dose-response relationship between measured vibration from repeated impact tools and the development of specified health conditions.
5. Assessment of risk from repeated impact tools should include assessment of potential ergonomic risks (e.g. from gripping or posture) as well as vibration risks.

Background

Vibration is defined as an oscillating movement of an article around an axis, or equilibrium point. It is characterised by frequency and amplitude, which determine the acceleration, being the rate of change of velocity.

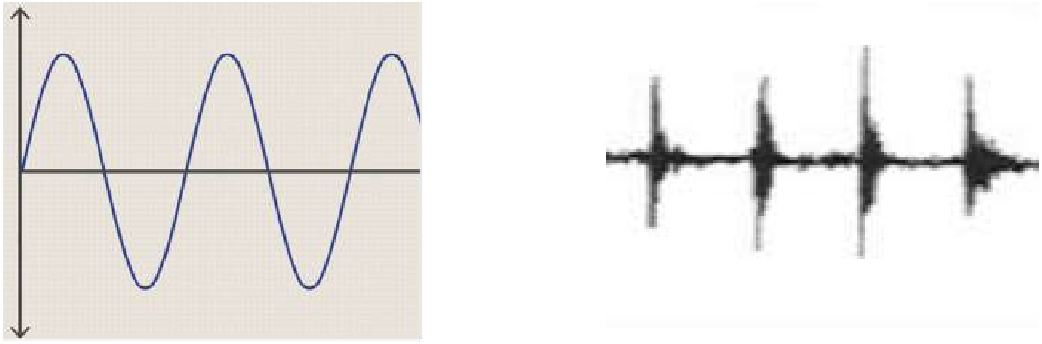
When considering health effects, the vibration that is emitted by a tool is described using three key features – being the frequency, the acceleration, and the direction of vibration. The frequency is considered as part of the measurement process, by use of a weighting factor which gives a greater weighting to the frequency of vibration considered to be most harmful. This is allowed for in the measurement of vibration and is not generally otherwise quoted.

Estimates vary as to the frequencies considered to be causative of hand arm vibration syndrome (HAVS). Examples include 5.6 - 5000 Hz and 8Hz to about 1000Hz. Vibration is measured in three axes using an accelerometer, which is fastened to the tool, and a total ("tri-axial") vibration emission calculated using a "root sum of squares" formula. Vibration exposure that is intermittent during the working day is adjusted to an equivalent 8-hour exposure level, to allow for further standardisation in assessment of risk; this is known as the A(8) level.

There are a number of tools such as nail guns and staple guns in which impact forces may have greater importance than regular vibration as described above. When considering the use of nail guns or staple guns, the duration of vibration associated with each nail or staple insertion is likely to be extremely short. This was highlighted by an HSE specialist noise and vibration inspector in a lecture in February 2020[1], in which it was stated that 'the time it takes for a nail gun to fire can be a fraction of a second (0.2- 0.5 seconds)'.

Impact forces differ from vibration in a number of important respects. Each impact is defined by a single application of force, which may then be accompanied by a very short period of vibration which very rapidly decays to zero. Hence, for each impact, there is no specific frequency of vibration, amplitude or acceleration but rather there is a tendency of each of those to peak at or immediately after the impact and then reduce over a very short period of time. This is shown in simplistic terms in the figure below.

Figure 1: comparison between continuous vibration (L) and repeated impact (R)



The distinction between hand transmitted vibration and impact/ shock forces was summarised in a 2021 article by S Hewitt (previously an HSE specialist in HAVS) et al, in which it was stated that 'a nail gun transmits energy into the operator's hands and arms in the form of isolated short-duration shocks. This can be called vibration although it is different from use of a grinder, chainsaw or demolition hammer' [2].

The use of repeated impact tools may be associated with risks other than those form the impact or vibration, such as wrist posture, repeated gripping and repetitive movement. These risks should be assessed in addition to those associated with possible vibration exposure.

Risk assessment

At an International Expert Workshop on Isolated and Repeated Shock Vibration international workshop in 2015 it was noted that 'at present ... no internationally generally accepted method is known for assessment of the risks presented by isolated shocks'[3]. Referring to measurement methods as in ISO 5349 -1: 2001 that 'experts doubt whether isolated shocks ... can be correctly recorded and assessed by means of these methods' [4]. In a 1993 study into fingertip vibration sensation, Meada and Griffin observed that 'results suggest that the equal energy hypothesis underlying BS 6842 and ISO5349 is inappropriate for the prediction of temporary threshold shift produced by repetitive shocks'[5].

ISO 5349-1 includes the statements 'the values obtained (by measurements as specified in the ISO) can be used to predict adverse effects of hand transmitted vibration over the frequency range covered by the octave bands from 8Hz to 1000Hz...provisionally this part of ISO 5349 is also applicable to repeated shock type excitation (impact)' and 'the time dependency for human response to repeated shocks is not fully known. Application of this part of ISO 5349 for such vibration is to be made with caution'[4]. However note 1 of ISO 5349 states 'in the case of exposing the worker to multiple single shocks or transient vibration, the method described in ISO 5349-1 may not be adequate and may under-estimate the severity of shock exposure'. However, this is conjectural, and does not reflect the absence of epidemiological evidence of health effects of impact work, which is why the data relied upon in the case of continuously operating vibrating equipment cannot be relied upon when calculating potential vibration risk in relation to repeated isolated shocks.

International Technical Specification, ISO/TS 15694: 2003[6] was developed to address the issue of the high shock content of the vibration from fastener driving tools, and states that 'the effects of repeated shock-type excitations on the hand-arm system are not fully understood' and that 'there is insufficient knowledge to establish whether the methods in ISO5349-1 (the standard for measurement and evaluation of human exposure to hand-transmitted vibration which specifies measurement of the RMS frequency-weighted acceleration) can be used for the assessment of the health risks from shock-type loading of the hand and arm'.

Hewitt et al[2] noted that 'it is also uncertain if measured vibration magnitudes on nail guns and vibration exposures can be relied on to indicate the risk of developing and upper limb disorder such as CTS or HAVS. So whilst a daily vibration exposure (the A(8) value) may be estimated for the use of a nail gun, arguably it would not be meaningful to compare (as an indicator of risk) this with thresholds such as the 2.5 m/sec^2 EAV of the Control of Vibration at Work regulations'.

In summary, given the uncertainty regarding the relationship between exposure to impact vibration and clearly defined health effect, the use of calculated daily exposure to vibration to quantify risk of development of health effects is open to challenge. Nevertheless, regulation 5 of the Control of Vibration at Work regulations 2005 states that the risk assessment shall include consideration of the magnitude, type and duration of exposure, including any exposure to intermittent vibration or repeated shocks[7]. Neither the regulations nor HSE Guidance I140 define repeated shocks for this purpose. In 2015 it was suggested at the International Expert Workshop on Isolated and Repeated Shock Vibration[3] that in respect of perceived shock (impact) exposure, a threshold of 15 per second should be used to distinguish between repeated isolated shocks and a continuous series of shocks, and a threshold of 25 per second to characterise stochastic (i.e. intermittent, non-continuous) vibration. On that basis, use of a nail gun or staple gun (which involves a repetition rate of well below 15 per second) is regarded as involving repeated isolated shocks rather than continuous vibration exposure.

Measurement of impact forces

The measurement of vibration from impact tools such as nail guns or staple guns may be very difficult, to the extent of sometimes being unreliable, because of the effect of the large impulse on the accelerometer and some measuring equipment, which is designed for measuring consistent vibration forces rather than high impact forces of extremely brief duration. Nevertheless, some equipment is able to measure impact vibration.

ISO 5349-1[4] recommends the use of a frequency filter known as Wh, when measuring emission of vibration from tools. This is intended to reflect 'the assumed importance of different frequencies in causing the injury to the hand"' and thereby give a better indication of the likely risk of harm. However, filters which are appropriate for vibration measurement may distort the measurement of impact forces[8]. HSE Research Report RR591 (2007)[9] was intended specifically to provide HSE with information regarding vibration measurements from single shocks and compare methods of measurement with those based on frequency weighted acceleration values, as used in relation to HAVS.

This was a limited study and assessed eleven tools using pine wood as the work piece, concluding that there was evidence of a consistent level of vibration exposure under standard conditions working on pine wood. Of particular note is that the measured emission levels from these tools were within a narrow range, and broadly consistent with the data provided by the manufacturers. Importantly however the statement was made that 'the relationship between the vibration magnitude measured, whether frequency-weighted or $flat_h$ weighted, and the likelihood of injury to the operator is still an area that is not understood'. In that report it was concluded that

a. Use of an alternative metric to frequency-weighted acceleration, … may well be a more appropriate technique for assessing the vibration characteristics of single shot tools and for identifying low and high vibration machines, and

b. It is well recognised, however, that when the vibration consists of a series of single shocks, as with fastener driving tools, the RMS frequency-weighted acceleration may not be the most appropriate way to quantify the vibration.

It was also concluded in that research report that:

c. In practice there was little effect on measured frequency-weighted acceleration by the work piece and fastener size.

d. The act of 'bumping' the tool on the work piece to activate the firing mechanism caused the vibration magnitudes measured to increase. Clearly the amount of force applied when 'bumping' the tool, will define how much the levels increase.

e. In-use vibration magnitudes were very similar for all of the nail guns, the heavy wire stapler and corrugated fastener. The range of mean, normalised vibration magnitudes from these tools is 3m/sec^2 to 4m/sec^2. The two fine wire staplers and the bradder were found to give vibration levels in the range of 1.4 - 1.8 m/sec^2. The authors concluded that 'these are very narrow ranges of data, indicating that the vibration magnitude measured from tools of the same type is very similar and also very repeatable'.

However, as noted above, it is important to consider these conclusions against the background of the fact that this was a limited study and assessed eleven tools using pine wood as the work piece. It is unclear whether these observations can be extrapolated to other materials and working conditions.

Duration of exposure with impact tools

Paragraph 5.3 (d) of ISO 5349-2[10] states that 'some operations involve exposure to short duration bursts of vibration exposure, this may be single or multiple shocks, such as riveting hammers, nail guns etc....in such cases it is often difficult to make an evaluation of actual exposure times although the number of bursts of vibration per day can be estimated.' One approach is to use data for the duration for each shock – either measured, observed or from manufacturer's data, and multiply that by the number of shocks within the measured time. That may be, for example, the number of staples or nails used.

Methods of calculating daily exposure

There are several different methods of calculating daily exposure due to sporadic vibration, one of which is based on the following calculation:

$$A(8) = a_{hw}\sqrt{\frac{N_{ePD}}{N_{test}} x \frac{T_{test}}{T_0}}$$

Where:

a_{hw} = vibration magnitude measured for the emission test or brief sample

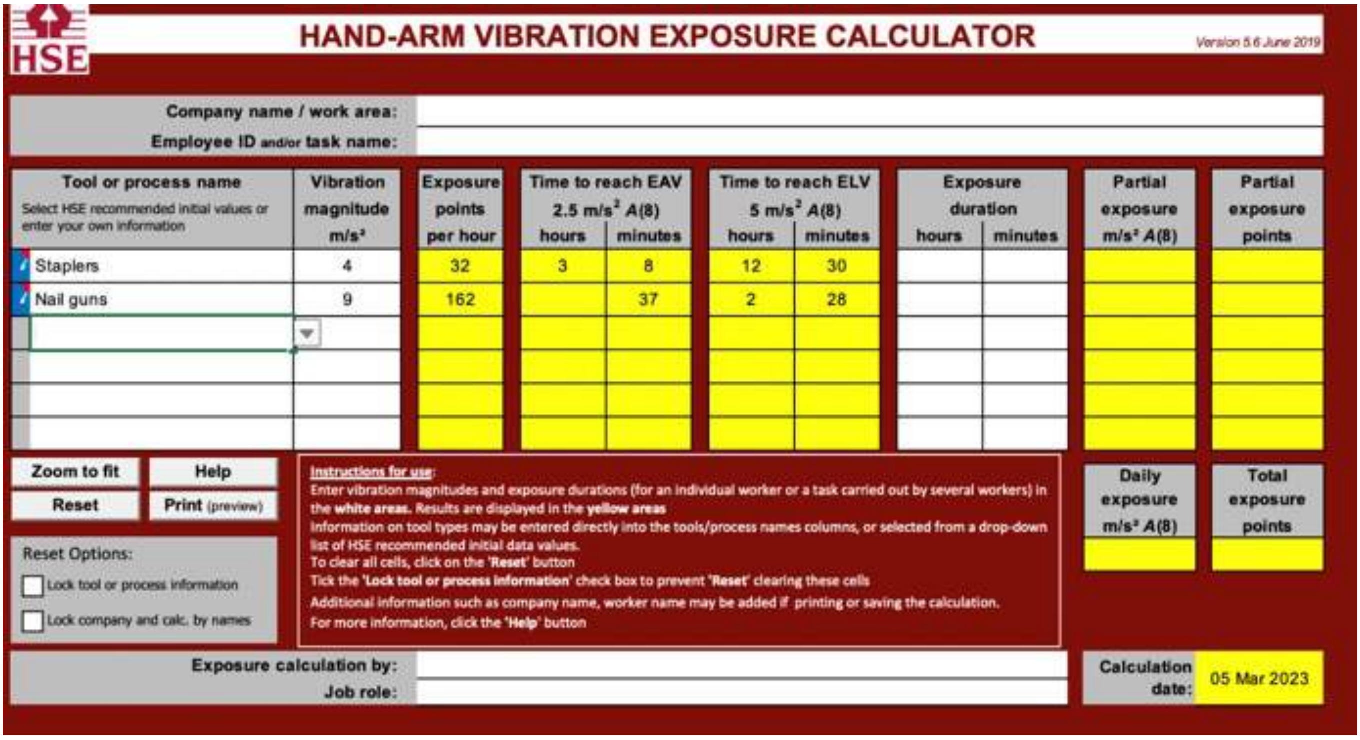
N_{ePD} = no. of shots fired by the operator of the tool per day

N_{test} = no. of shots fired during the test measurement

T_{Test} = duration of test measurement

T_0 = reference exposure time of 8 hours, which is 28800 seconds.

The HSE has developed a vibration exposure calculator for single impact tools which is based on this equation. Appendix P of RR 591[9]states that 'calculation of A(8) from vibration magnitude and exposure time information can be done using the HSE vibration calculator, which can be downloaded free from the HSE website'. The current version of the HSE vibration calculator, on the HSE website, includes a drop down menu for tools and suggested vibration emission levels (see below). That includes an emission level of 4 m/sec^2 for staplers and 9 m/sec^2 for nail guns, indicating an expectation that daily exposure of employees with exposure from these tools should be undertaken using this approach. It is notable that Schedule 1 to the Control of Vibration at Work regulations 2005 defines the method to be used to ascertain the daily exposure (A(8)) of an exposed person, which based on this method.



HSE Guidance

IND(G) 175 - HSE guidance for employers concerning hand arm vibration at work – makes no reference to nail guns or staple guns and does not include furniture manufacture among the list of jobs most likely to create a risk[11]. Specifically, it does not include nail guns/ staple guns among the list of types of equipment most likely to create a risk. At the time of writing this document HSE on line advice regarding nail guns refers to accidents and noise effects but does not identify exposure to vibration as a specific hazard associated with this type of tool[12]. That page of the HSE website makes no comment regarding vibration or impact, and the guidance does not contain a link to the Control of Vibration at Work regulations or any associated guidance.

Health effects of impact forces

The effects of impact forces on the hand are likely to be different from those of vibration and reflect the manner of in which the impact is transmitted to the hand. The different effects of impact and non-impact vibration were identified in 1997[13], and it was noted that low frequency impact (50 Hz or less) tended to be transmitted to the upper arm, whilst higher frequency impact vibration (more than 100 Hz) tended to be attenuated in the wrist and hand, and therefore caused symptoms in those areas.

A range of conditions may be caused by impact forces, and symptoms caused by impact forces may be sufficient to cause the worker to adapt their grip or posture in an attempt to alleviate such symptoms. This may also aggravate issues related to posture necessitated by the nature of the work. Table 1 summarises some of the conditions possibly caused by impact forces. However, caution should be exercised before concluding that the individual's condition relates to the use of repeated impact from power tools.

Table 1 – Some of the conditions possibly caused by impact forces

Type of condition	Example
Skin & subcutaneous	Beat hand (PD A5)
Dupuytrens disease	
Ligamentous	Skier's/ Gamekeeper's thumb
	Trigger finger
	Lumbrical plus deformity
Stress fractures	Ulnar styloid
Kienbock's diease	
Vascular	Thenar hammer syndrome
	Hypothenar hammer syndrome
	Palmar arch disease
	Digital artery aneurysm
Neurological	Median nerve - carpal tunnel syndrome
	Ulnar nerve - Guyon tunnel syndrome
	Radial nerve - Wartneberg's cheiralgia

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14. WHOLE BODY VIBRATION (WBV)

Written by Dr Roger Cooke

Introduction

1. The following has been produced by members of the Society of Occupational Medicine HAVS Special Interest Group as a resource to assist those involved in the diagnosis and management of workers potentially exposed to whole body vibration (WBV).
2. This guide does not aim to be a comprehensive overview of WBV, nor does it seek to replace existing guidelines or formal education. Rather, it is a practical summary intended to provide background information and assist practitioners who may be asked to advise about the subject.
3. The guide has been prepared by members of a working group set up by the Society of Occupational Medicine (SOM) but 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 Society.
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 WBV accords with best current practice, and legal requirements, and the SOM will accept no responsibility resulting from the failure of any reader to do so.
5. The Special Interest Group (SIG) welcomes any comments or suggestions regarding this publication. The SOM will assist members by directing specific enquiries about WBV, hand-arm vibration syndrome (HAVS) or carpal tunnel syndrome (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. 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 individualised subject factors. However, the evidence may be limited in its relevance and applicability, as is often the case in WBV.
8. The aim of this document is to provide general advice on WBV and combine a review of the best available evidence for management with current expert practice. Accordingly, the document aims to summarise the evidence currently available relating to WBV in a concise and easily readable form, and provides consensus views of the group in respect of that evidence.
9. The document has been developed primarily for occupational health practitioners who are engaged with managing and supporting workers with exposure to WBV. It can 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 the management of WBV in the workplace. It should be read in conjunction with SOM documents on HAVS and CTS, and Health and Safety Executive (HSE) guidance L141.

Key messages

1. Health effects of WBV are generally poorly defined, although there is evidence that indicates an effect on the lumbar spine and associated tissues.
2. It is important to distinguish between whole body vibration and local effects of regional vibration.
3. While risk assessment is required under the Control of Vibration at Work Regulations, there is insufficient data to relate measured exposure to WBV to the likelihood of an individual developing adverse health effects.
4. Cases of back pain in those exposed to WBV require a holistic assessment, to include consideration of other medical causes, as well as other workplace factors such as posture and ergonomics.
5. Routine health surveillance is not appropriate for WBV.
6. Monitoring for back pain can be undertaken as part of other general health monitoring.
7. A pragmatic approach is required in managing those with back pain apparently associated with WBV exposure, with consideration of all possible relevant factors.
8. While further evidence is required regarding the effect of WBV on pregnancy, some reports suggest a potential effect and a cautious approach appears to be appropriate when offering advice to employees.

Whole Body Vibration (WBV)

Whole body vibration (WBV) refers to the generalised effects of exposure of the whole body to vibration. It is defined in HSE guidance INDG242 as "the generalised effects of exposure of the whole body to vibration, usually by sitting in a tractor or other vehicle, but also when an individual is standing on a vibrating platform". [1]

In 2000 it was estimated that 7.2 million men and 1.8 million women in the UK are exposed on a weekly basis to occupational WBV.[2] Another earlier study showed higher prevalences in farming, forestry and road transport, where 12% of men and 1% of women reported their job involved sitting or standing on a vibrating machine or vehicle.[3] It has also been estimated that 2.7% of the US workforce is exposed to WBV each day – which equates to 3.5 million workers.[4]

A review of relevant literature was published by the HSE in 2001, and referred to a 1931 paper by Reiher and Meister which stated that *"the deleterious effects of street and machine vibrations are known"*.[5] Potential sources of WBV are listed in HSE guidance ref INDG242 (Table 1), which also states that *"most people who drive road-going vehicles at work are not likely to experience high levels of whole-body vibration and so their employers are unlikely to have to take any action under these Regulations"*.

Table 1: Examples of sources of whole body vibration. *Ref: HSE INDG242*

- **Off-road mobile machinery**
- **Agricultural vehicles or industrial trucks**
- **Drivers of other vehicles, particularly if they suffer from back pain**
- **Standing on a structure attached to a large, powerful, fixed machine which is impacting or vibrating**
- **FLTs driven over poor surfaces**

Measurement of Whole Body Vibration Exposure

As for hand-transmitted vibration (HTV), WBV is measured in three axes using an accelerometer. It is expressed as an acceleration in units of metre/sec/sec or ms-2. In HTV, a root sum of squares of vibration in each of the three axes is used to calculate total vibration. However, the value used for calculating daily exposure to WBV – the daily A(8) – is the highest of the frequency-weighted measurements taken in each of the three axes. The HSE have a WBV exposure calculator to assist this process. (See https://www.hse.gov.uk/vibration/wbv/calculator.htm)

Unfortunately, the lack of epidemiological evidence means that measurement of WBV exposure levels and calculation of daily A(8) exposure does not allow prediction of adverse health effects, or estimation of risks of such effects in an exposed individual.

Measurement of the vibration dose value (VDV) is believed to give a better indication of vibration including shocks, and is a cumulative value based on the cumulative dose but is not used for the purposes of risk assessment in the UK. Irrespective of which exposure index is adopted, WBV measurements should be carried out in accordance with ISO 2631-1.

Mechanisms of damage from Whole Body Vibration

There are two potential routes via which exposure to WBV may have a pathological effect – either directly via transmission of vibrational energy into the whole body or via resonance. It is also likely that most WBV is a combination of 'regular' vibration and impact forces, so any relationship between such exposure and putative health effects will be complex and difficult to define. It is possible that repeated muscular contractions occur around these resonant frequencies, and contribute to symptoms of pain, aching and fatigue.

Resonance is the frequency at which vibration is amplified rather than attenuated. Whole body resonance has been estimated by a number of authors – see Table 2. In line with such estimates, Grether found that discomfort from WBV peaked at about 5 Hz – the level at which there is greatest resonance of the large organs of the body. Individual organs within the body have differing resonances – see Table 3.

- **Standing** 8–10 Hz (Ji et al. 1995)
- **Standing** 9–16 Hz Independent of mass height and BMI (Randall et al. 1997)
- **Seated** 5 Hz with second mode about 10 Hz
- **Standing** 5.5 Hz with second band 9–14 Hz
- **Sitting** 4–6 Hz (absorbed power) (Fairley & Griffin 1998)

Table 2: Examples of estimated frequency of whole body resonance

Organs	Resonance Frequencies (Hz)
Head	20 to 40
Spinal column	8
Chest wall	60
Abdominal	4 to 8
Shoulders	4 to 8
Lungs	4 to 8
Hands & arms	20 to 70
Ocular globe	60 to 90
Maxilla	100 to 200

Table 3: After Duarte 2006 [7]

Potential health effects of Whole Body Vibration

Back pain, sciatica and lumbar disc degeneration are the most commonly discussed health effects of WBV, although effects due to individual organ resonance remain a possibility. ISO 2631 (2018) Annex B[8] states that WBV health effects include an increased risk to the lower lumbar spine and connected nervous system of the segments affected. Other factors such as bending forward or twisting are likely to increase any adverse health effects.

Health effects of WBV on the cervical spine and autonomic and gastrointestinal systems are not supported by evidence. [9, 10, 11] In his Handbook of Human Vibration, Professor M J Griffin describes the effects of WBV[12], and divides those effects into five groups: degraded comfort, interference with activities, impaired health, perception of low-magnitude vibration and motion sickness. A summary of possible health effects of WBV is given in Table 4 below.

Table 4: Possible health effects of WBV

Acute effects	Chronic effects
Postural control – <1 Hz or > 15 Hz	Spinal column – back pain, sciatica, lumbar disc degeneration
Vestibular dysfunction	Gastrointestinal
Altered stomach motility	Autonomic
Muscle fatigue	Neurological
General fatigue	Cardiovascular
Headache	Reproductive
Cognitive function, concentration and drowsiness	Renal
Discomfort, nausea, motion sickness, mal de debarquement	

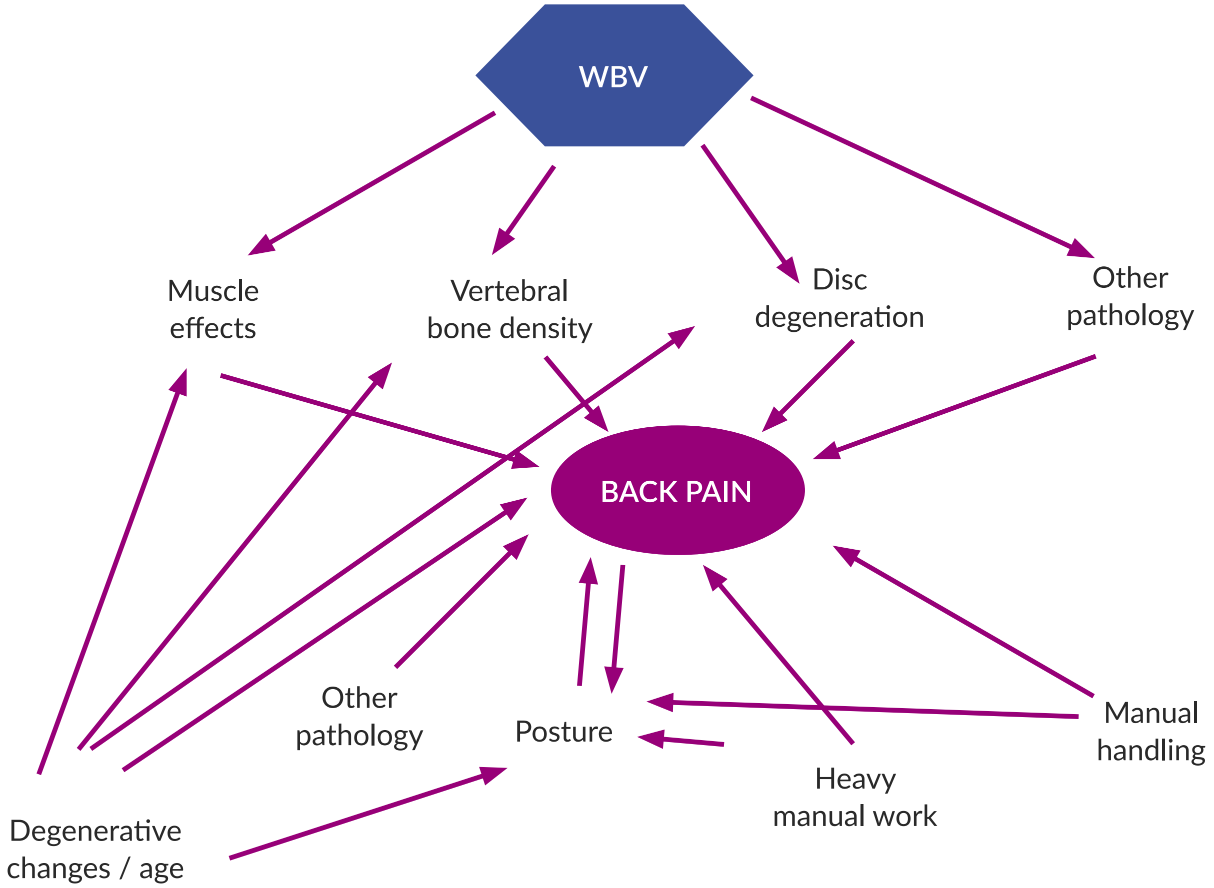
WBV, the spine and back pain

There is an extremely wide range of factors with potential to influence the development of back pain in an individual (see Table 5), making the role of WBV difficult to define, when considered in the context of constitutional factors, other underlying conditions and potential ergonomic influences. Nevertheless there is evidence that WBV does affect the lumbar spine in several ways,[14] including inflammatory and degenerative changes, reduced vertebral density, cartilaginous endplate tears and changes to the intervertebral discs. Some studies have shown a high rate of degenerative spinal changes – as demonstrated by X-ray, CT or MRI – although there is poor correlation between such changes and the nature and severity of symptoms reported, either generally or in respect of WBV.

An exposure threshold effect has yet to be determined for WBV.

Where an individual presents with back pain potentially related to WBV exposure, workplace assessment should include all aspects of ergonomics as well as WBV assessment. The aggravation of symptoms of back pain from exposure to WBV should be addressed pragmatically; in which circumstances, removal from such exposure may be appropriate.

Table 5: Potential contributors to back pain (Cooke, 2022)



WBV and pregnancy

In 1993 a review by Seidel concluded that 'increased risks of abortions, menstrual disturbances, and abnormalities of positions can be assumed to be associated with long term exposures to WBV'.[15]

Animal studies have demonstrated effects that could explain an effect of WBV on pregnancy. For example there is evidence that vibrations can be transmitted to the foetus; one study identified the resonant frequency of sheep uterus as between 6 and 18 Hz.[16] Nakemura et al[17] found that uterine blood flow was decreased in pregnant rats 75-90 minutes after exposure to vibration at 10m/s2 and 8Hz, although the relevance of this is unclear given that this is significantly higher than any current occupational exposure limit. Progesterone and prostaglandin E2 were also reduced, with the latter providing a potential explanation for the decreased uterine blood flow.

Vibration has been reported as an occupational risk factor for nuisance and for complications of pregnancy, such as premature birth and low child birth weight.[18] In 2018 Kromka-Szydek et al reported subjective responses to WBV in public transport or cars[19], noting that the frequency of vibration was typically 5-6.3 Hz, compared with abdominal organ resonant frequencies of 4.5 – 10Hz. While acknowledging the subjectivity of their findings these authors reported that travelling by car produced digestive disorders and increased foetal activity, while tram riding was associated with digestive disorders and headaches.

In 2007, Croteau et al[20] reported a significant increase in preterm delivery for mothers exposed to demanding posture for at least three hours per day, occupational whole-body vibration at the start of the pregnancy (OR 1.8, 95% CI 1.1-2.76), and high job strain combined with low or moderate social support. There was a similar association between these factors and very pre-term delivery (i.e. less than 34 weeks gestation). In this study information was collected by telephone after the childbirth, including self-reported occupational conditions, such as whole-body vibration at the start of and during the pregnancy. The authors acknowledged the possibility of recall bias. In addition the determination of vibration exposure was binary (yes/no) with no validation of the reported exposure, or analysis relating pregnancy outcome to estimated level of daily exposure. However their findings accorded with previous work by Mamelle et al in 1984, who reported weak epidemiological evidence (OR 1.7 95%CI 1.0-2.2) of prematurity being associated with "work on industrial machine" which might involve vibration 21, and that of Haelterman, E. et al in 2007 who concluded that WBV exposure was associated with preeclampsia, but non-significantly, (OR 1.4, 95% CI 0.7-2.8).[22]

In 2021, Skröder et al. reported a retrospective nationwide cohort study considering the effect of occupational WBV during pregnancy and found an increased risk for pre-term birth among women who were exposed to WBV compared to women who were not exposed.[23] In this study exposure was estimated using data from a range of existing sources, with ranges of exposure being assigned to specific job (occupational) codes (0 m/sec2, 0.1-0.2 m/sec2 , 0.3 – 0.4 m/sec2 and 0.5 m/sec2 or greater). In addition, a group of occupations with exposure to mechanical shocks was identified. They found that exposure to WBV in the highest exposure group was associated with an increased risk of preeclampsia, gestational hypertension and gestational diabetes among full-time workers, compared with non-exposed women. They acknowledged that further research is needed.

Conclusion

In 2009, Joubert et al concluded that there was "unclear and weak evidence of adverse reproductive outcomes" associated with prolonged exposure to whole-body vibration, but that the possibility should not be ignored.[24] The paper by Skroder et al[23] appears to provide stronger evidence of such an effect of WBV, but while this research provides the best evidence to date, conclusions are limited by the difficulty in assessing individual exposure to WBV. Based on their findings, they suggest that women should not be exposed to WBV at or above the action limit value of 0.5m/s2 continuously through pregnancy. While – in their words – these results need further confirmation, a cautious approach appears appropriate when offering occupational health advice to employees.

Regional /segmental effects of vibration

When considering WBV, it is important to recognise the distinction between regional vibration (sometimes referred to as segmental) and general (whole body) vibration. This is particularly important when considering symptoms attributed to vibration exposure.

Regional effects of vibration are most commonly seen in the fingers and thumbs as HAVS, although it is plausible that regional vibration occurs elsewhere, such as in the toes or the feet, where those parts of the body are exposed to vibration. The two main effects of regional vibration exposure are vascular, causing Raynaud's phenomenon, and sensorineural, causing sensory symptoms of tingling and/or numbness as a result of damage to the nerve endings and associated fine nervous tissue in the fingertips. Raynaud's phenomenon is due to episodic vasospasm of the peripheral arteries – in the case of the hands or the feet, the digital arteries.

Tingling and/or numbness may occur as a normal response to regional vibration exposure due to sensorineural effects, but those symptoms may become more protracted, and eventually permanent, with abnormalities on clinical examination.

CTS may occur in association with use of handheld vibratory tools, although there is debate as to whether that is due to ergonomic and postural effects or the vibration exposure itself. Where CTS occurs, for whatever cause, symptoms may affect the digits, palm and lower part of the forearm.

Vibration and the feet

If one accepts that an effect of regional vibration exposure to the feet would follow the same pathological course as hand-transmitted vibration (which is hypothesis, and not proven), then one might expect a similar process of development of symptoms in the feet exposed to vibration. However, the effect of localised vibration on the feet is poorly defined.

In 2010 it was noted that "a condition analogous to HAVS might occur in the feet after lower extremity vibration exposure is biologically plausible, though not well studied".[25] In that case report there was no neurological abnormality of the feet. A later (2014) review referred to foot-transmitted vibration (FTV), being distinct from hand-transmitted vibration or whole body vibration.[26] The authors noted that "little is known about the characteristics of occupational FTV or clinical implications with prolonged exposure", and that a clear dose response relationship has yet to be proven. That review cited only two published reports of "vibration white toes". In one of those there was a mild neurological deficit in the affected foot. The review concluded that "study is required to … better characterize and control foot transmitted vibration" and that "epidemiological evidence is required to link (foot vibration) exposure with injury".

In summary, therefore, neurological effects of regional vibration exposure to the feet are poorly defined or reported, and while there is a plausible argument that such effects may occur, as they do in the fingers, that has not been confirmed by epidemiological or other studies.

Some authorities accept that vascular symptoms of Raynaud's phenomenon may occur in the feet following local exposure of the hands to vibration, i.e. without apparent local exposure of the feet.[27] There is a lack of clear evidence in epidemiology or a pathological basis for this, although a sympathetic reflex phenomenon is a putative explanation.[28] It is notable that both toes and fingers are affected in less than half of cases of primary/constitutional Raynaud's; one early study found that 42.6% had both fingers and toes involved and 1% the toes only.[29]

Vibroaccoustic disease

Vibroacoustic disease was first described in 1987, as a whole-body pathology associated with long-term exposure to high-intensity, low-frequency noise exposure (20–500 Hz).[30] It is believed to reflect a range of pathologies such as cardiovascular changes including pericardial thickening, respiratory and gastrointestinal symptoms and psychological disorders including depression, irritability and aggression. The similarity between very low-frequency noise and vibration is such that there is a possibility of overlap with WBV.

Legislation and HSE guidance

The Control of Vibration at Work Regulations 2005 (CoVaW)[31] cover whole body vibration as well as hand-arm vibration. Regulation 2 of CoVaW defines whole body vibration as *"mechanical vibration, which is transmitted into the body, when seated or standing, through the supporting surface, during a work activity or as described in regulation 5(3)(f). Regulation 5(3)(f) extends the scope of WBV exposure to include any extension of exposure at the workplace to whole-body vibration beyond normal working hours, including exposure in rest facilities supervised by the employer"*.

The Health and Safety Executive (HSE) has published guidance on WBV, in HSE guidance document L141.[32] Paragraph 13 of that document states that *"the Vibration Regulations are designed to protect against risks to both health and safety from whole-body vibration, i.e. the risk of back pain in those exposed and situations where vibration may affect ability to handle controls or read indicators"*. L141 focuses on back pain associated with WBV exposure, and contains no specific reference to either vascular or neurological effects on the feet.

The Control of Vibration at Work Regulations (2005) define an exposure action value (EAV) and an exposure limit value (ELV) for WBV. For whole body vibration, the daily ELV – the maximum amount of exposure to which an employee may be exposed on any single day – is 1.15 m/s^2 A(8). The daily EAV is defined in paragraph 28 of L141 as that level *"above which you are required to take actions to reduce exposure"* – 0.5 m/s2 A(8). However, Regulation 6 includes an overriding duty to reduce exposure to as low a level as reasonably practicable.

Risk assessment

HSE guidance document INDG242 states that "you don't have to (measure employees' exposure) as long as you have done the broad risk assessment and take all the appropriate and reasonable control actions described in this leaflet". That reflects paragraph 41 of HSE guidance L141, which states that "an assessment of exposure based on published information will normally be adequate … but you will need to be able to show … that the measures you have put in place will prevent the exposure limit value being exceeded. If you cannot do this using published data, you may have to arrange for measurements to be taken".

It is noted that driving vehicles solely on-road is unlikely to result in the EAV being exceeded, unless the vehicles have poor suspension and are driven for most of a working day or shift, and that in most cases where the evidence suggests that exposure is unlikely to exceed the EAV, it will be sufficient to record that fact.

When undertaking a risk assessment for WBV, a number of factors should be considered in addition to the vibration, including:

1. adverse postural influences from
    a. poor design of controls such that the driver has to twist, bend, lean or stretch in order to operate the vehicle
    b. inadequate adjustment of seats and controls
    c. sitting in one position for prolonged periods
2. manual handling risks
3. other risks associated with access to and egress from a high or difficult access cab.

Health surveillance/Monitoring

CoVaW Regulation 7(2) states that "health surveillance, which shall be intended to prevent or diagnose any health effect linked with exposure to vibration, shall be appropriate where the exposure of the employee to vibration is such that

a. a link can be established between that exposure and an identifiable disease or adverse health effect
b. it is probable that the disease or effect may occur under the particular conditions of his work, and
c. there are valid techniques for detecting the disease or effect."

It is evident that these criteria are not met in respect of WBV and back pain, and hence routine health surveillance is not appropriate for WBV. This is confirmed as the HSE position in paragraph 22 of guidance L141, which states that "health surveillance (regulation 3(4)(a)) is not appropriate for WBV because it is considered that no methods currently exist for detecting changes in people's backs, which can reliably indicate the early onset of changes (which may cause low back pain) that are specifically related to workplace factors".

The HSE suggest that 'health monitoring' may be helpful, but this is not a legal requirement under the CoVaW Regulations, and reflects a holistic approach to back pain, using an annual checklist for employees at risk. This might reasonably be included as part of a driver's assessment or a 'safety critical worker' health review. A sample questionnaire is included in L141 (see Appendix A).

There is likely to be a value in pre-placement assessment of those with existing back pain, in which case all the ergonomic and manual handling issues should be considered as well as possible effects of WBV. In addition, early reporting of back pain symptoms, with assessment and treatment should be encouraged.

Positive effects of whole body vibration Whole body vibration therapy is being suggested as having health benefits including improvement of bone density in post-menopausal women,[33] increased levels of growth hormone and testosterone,[34] improved walking performance after stroke and with OA knee[35] and control of type 2 diabetes.[36]

However, while these reports provide further evidence that WBV has a physiological/pathological effect on the body, extrapolation of this into workplace effects has yet to be considered. In addition the concept of 'work-hardening' is probably not appropriate for the "complex, seated, jolt/vibration environment" found in WBV exposure.[37]

Appendix:
HEALTH QUESTIONNAIRE AS RECOMMENDED IN HSE L141

	YES	NO
Any changes in duties/hours since last questionnaire?		
Recent experience		
Is there **currently** any movement or activity that causes you pain in your back?		
Have you suffered any back/neck/shoulder pain **in the last 12 months?**		

Please describe the severity of the pain experienced:

No pain										Pain as bad as it could be
0	1	2	3	4	5	6	7	8	9	10

Note: if severity above 5 indicated, refer on for further advice.
*However, if rank less than 5, but for three consecutive assessments, then refer for further advice.**

	YES	NO
Have you had to take any medication to deal with the pain experienced?	*	
Have you had to seek medical advice regarding this pain?	*	
Has this back/neck/shoulder pain resulted in time off from work?	*	
Have you had any accidents or injury to the back in the last two years?	*	

Action / advice

Referral for further advice?

Other advice provided?

Note: where answers occur in the boxes marked with an asterisk (*), the HSE recommends that further advice should be sought from an occupational health professional or GP.

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15. MANAGEMENT OF EMPLOYEES WITH HAVS AND CTS

Written by Dr Chandra Mutalik, Dr Dominic Haseldine and Dr Roger Cooke (August 2019)

Hand-transmitted vibration (HTV) can cause Hand-arm Vibration Syndrome (HAVS), and possibly also Carpal Tunnel Syndrome. HSE use the abbreviation v-CTS to refer to cases of CTS thought to be due to the effects of vibration. The following summarises an approach to the management of these cases at work and should be read in conjunction with existing guidance, including that from the Health and Safety Executive (HSE).

General recommendations

The following applies to most cases of HAVS and v-CTS.

For employers:

- HAVS can lead to disability and a poor quality of life for the employee, but timely recognition and management of this condition might help to reduce progression and improve functional outcomes. There can be safety and legal consequences for the employer. The main aim of health surveillance is to detect HAVS or v-CTS at an early stage to help prevent it from progressing to a disabling loss of hand function.
- If work involves exposure to HTV, the employer is required to do a suitable and sufficient risk assessment, reduce the exposure as far as is reasonably practicable, consider the need for health surveillance and identify measures that need to be taken to meet the requirements of the control of Vibration at Work Regulations 2005. The Regulations provide a daily exposure limit value (ELV) and exposure action value (EAV). The ELV is the maximum amount of HTV an employee may be exposed to on any single day and it is $5m/s^2$ A(8). The employer is required to undertake Health surveillance not only for employees likely to exceed at or above the EAV but also others whom the risk assessment identifies may be at risk. The EAV is $5m/s^2$ A(8). There is no safe level for HTV exposure since there can be considerable variation in individual susceptibility to vibration, but vibration related ill health is unreported for exposure below $1m/s^2$ A(8).
- A HAVS assessment should include calculation of the worker's daily exposure to HTV using the Health & Safety Executive's (HSE) vibration calculator and the employer should ensure that suitable control measures are in place. The exposure to HTV should be reduced to as low a level as reasonably practicable (ALARP) in accordance with the Regulations.
- Workers should be provided with information, instruction and training on monitoring of daily exposure to HTV, regular maintenance of vibrating tools and the use of personal protective equipment (PPE).
- A new case or significant worsening of HAVS or CTS is reportable to the HSE under RIDDOR. The decision to report is managerial, reflecting a doctor's diagnosis and workplace exposure to HTV.

For employees:

The symptoms of HAVS include tingling and numbness in the fingers and a reduced sense of touch, temperature and pain perception, reduced hand dexterity and grip strength, cold intolerance and attacks of white finger on exposure to cold or damp conditions. v-CTS can also cause tingling and numbness in the fingers, pain in the hand and forearm, and weak grip strength. The best course of treatment is early diagnosis and reduced exposure to HTV hence report any symptoms to the Responsible Person or occupational health promptly.

- If you are a smoker, consider smoking cessation as there is some evidence that this can improve the symptoms.
- If you experience attacks of white finger/blanching, ask your colleague or friend to take a photograph of the back and front of your hands during an attack. It can be helpful in the assessment and diagnosis of HAVS.

HAVS and v-CTS caused by exposure to HTV at work are Prescribed Diseases and the worker may be eligible for Industrial Injury Disablement Benefit.

Specific recommendations

HAVS stage 1v and/or 1sn:

- Advise management and worker to reduce exposure to HTV at work ALARP in accordance with the Control of Vibration at Work Regulations 2005.
- Advise management to report the case to the HSE under RIDDOR.
- If the latent period suggests particular susceptibility to HTV, consider having more frequent HAVS health surveillance to monitor for progression of the disease. This could be done by an occupational health nurse or an occupational physician according to training and skill level.

HAVS stage 2v (early) and/or 2sn (early):

If an employee is diagnosed with HAVS stage 2 early, the aim is to prevent progression to stage 2 late or stage 3 because more severe forms of the disease are associated with a significant loss of function and disability.

- Advise management and worker to reduce exposure to HTV at work ALARP in accordance with the Control of Vibration at Work Regulations 2005 and certainly it should be less than the current level of exposure.
- Advise management to report the case to the HSE under RIDDOR unless previously reported.
- The frequency of health surveillance should be increased to monitor for progression of the disease. This could be done by an occupational health nurse or an occupational physician according to training and skill level.
- Sometimes it can be challenging to differentiate between stage 2 early and 2 late. Consider referral for tier 5 assessment (quantitative sensory tests of thermal and vibration perception) to assess whether late stage 2 has been reached. Tier 5 may also provide a second medical opinion and access to other specialised tests. If the symptoms are progressing within HAVS stage 2, the doctor should consider whether to advise the employee to cease further exposure to HTV at work.
- An employee with blanching and an abnormal Allen's test should have further investigations via their GP such as blood investigations, Doppler ultrasound or MR angiography to rule out other conditions.

HAVS stage 2v (late) and/or 2sn (late) and Stage 3v and/or 3sn

- Progression to the late form of stage 2 and 3 is an indicator of the employee being unfit for work with vibration, however, consider the following before recommending restriction on further exposure:
- The available clinical methods for assessment and prediction of progression of HAVS are not necessarily precise, therefore the decision to advise the employer that an employee should stop further exposure to HTV at work involves a significant element of clinical judgement. For this reason, consider using standardised tests (Tier 5) to obtain more accurate information.

- Management of existing cases of late stage 2 and 3 HAVS is potentially different as more information may be available about the rate of progression over time. HSE Guidance L140 advises that an employee who has been monitored under health surveillance for a long period of time and has shown no progression of symptoms, and who fully understands the risks involved in ongoing exposure, may be allowed to continue work with limited exposure to HTV under frequent health surveillance. It is important to obtain employee's job description, risk assessment findings and details of control measures in place.
- Advise management to report the case to the HSE under RIDDOR unless previously reported.
- If there is an element of co-existing CTS, then this should be investigated with multi-segmental nerve conduction tests before diagnosing sensorineural HAVS.
- Depending on the severity of symptoms and functional impact, consider giving advice on whether the condition/impairment is likely to be covered as a disability under the Equality Act 2010.

Vibration-related Carpal Tunnel Syndrome (v-CTS)

The presentation of the sensorineural component of HAVS and CTS can be very similar and often indistinguishable. The following points should be considered while offering advice to the employer and employee:

If CTS is suspected:

- Advise the employee to consult a GP to consider multi-segmental nerve conduction tests to assess the severity of CTS and guide management.
- If the CTS due to work with vibratory tools is suspected, advice management and worker to reduce exposure to HTV at work ALARP in accordance with the Regulations.
- There is no evidence that HTV leads to exacerbation of pre-existing compressive CTS but work with vibrating tools involves other risk factors for CTS. The employer should 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:

- The employee may have to be removed from the exposure to HTV until he/she receives treatment.
- 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.

After CTS treatment:

Recommendations for a return to work with exposure to HTV should be made on an individual basis and the employee should be informed of the possible return of symptoms with continued exposure.

- Advise management and worker to reduce exposure to HTV at work ALARP and have more frequent health surveillance to identify the re-emergence of symptoms of CTS.
- The employer should undertake an ergonomic risk assessment of the job activities to assess other risk factors for CTS and to try to reduce the risk of relapse.
- If there is a relapse of CTS, consider permanent restriction on exposure to HTV at work.

16. PREPARATION, RECORDING AND AUDIT OF HAV CASE NOTES AND REPORTS

Written by Dr Danny Wong / Dr Simon Sheard (November 2018)

1. Purpose

This procedure describes how subject encounters for Hand-Arm Vibration Syndrome (HAVS) assessment are recorded in medical records in accordance with best practice in the form of an audit.

2. Scope

The recording of all subject HAVS clinical encounters including clinical and routine records either paper or electronic.

3. Definitions

HAVS Clinical encounter = all meetings between subject and nurse/doctor for clinical purposes related to Tier 1,2,3 and 4 HAVs

Clinician = physician, nurse, technician

4. Procedure for Audit of Case Notes

- ***Auditors*** Auditors may be a nurse and/or an occupational physician who are familiar with the clinical process, audit procedure and the health assessment to be audited. The nurse/occupational physician will not audit their own health assessments.
- ***Selection of records*** A date is selected at random by the auditor and the first records (number to be agreed) of HAVS assessments carried out from that date by a doctor and/or nurse to be audited will be selected by the auditor.
- ***Audit of records*** It is recommended an audit of notes be carried out on an annual basis. This is carried out by the auditor/s. The audit checklists are in the appendices to this paper.
- ***Reporting of results*** Individual nurse/doctor feedback will consist of the return of the completed checklists for each assessment audited, and discussion of significant conformities/improvement opportunities with the auditor. Documentation of the feedback will be at the auditor's discretion, but, as a minimum, discussion of significant findings/improvement opportunities must be documented and signed by both parties. The result may also be used for doctor, nurse revalidation/clinical appraisal.

REFERENCES

OH Consultations Policy NHS Plus V03:

SEQOHS - https://www.seqohs.org/

Hand-arm Vibration – The Control of Vibration at Work Regulations 2005 L140z

'Guidelines for records and record keeping': The Nursing and Midwifery Council Guidelines, dated 2004

Cumbria and the North East - Medical Appraisal & Revalidation https://www.cnegpappraisal.co.uk/

17. LEGAL CONSIDERATIONS

Written by Dr Danny Wong / Dr Simon Sheard (November 2018)

Main Statutory Guidance relating to Hand Arm Vibration

1. ***Health and Safety at Work, etc. Act 1974***
2. ***The Control of Vibration at Work Regulations 2005***
3. ***The Provision and Use of Work Equipment regulations***
4. ***The Management of Health and Safety at Work regulations***

Other relevant publications

Hand-arm vibration – Control of Vibration at Work Regulations 2005, HSE books L140 (2020)

Hand arm vibration – Inspection and Enforcement Guidance, HSE (2020)

Updated Guidance 2020 HSE, Hand Arm Vibration: Inspection and Enforcement Guidance, (July/August 2020) – available at https://www.hse.gov.uk/foi/internalops/og/ index.htm

This document replaces the HSE 2010 topic inspection pack is intended for the use of inspectors inspecting work activities involving risks from hand arm vibration. It is an "open government" document, and therefore accessible to all. By identifying issues which are regarded by HSE as relevant to control of risks from hand transmitted vibration, it may also assist others involved in reviewing such issues within workplaces. It is intended to cover all aspects of HAVS and CTS relevant to HSE inspection and enforcement, and the following notes identify only some of the issues that will be important to address.

Appendix 2 of this document is a table of factors to be considered in HAV inspections. Among many items the following are included for consideration by inspectors:

- whether the OH provider provides the employer with grouped anonymised health surveillance results (for more than 5 employees), and
- whether the OH provider has advised the employer (subject to employee consent) to reports cases of CTS and new and worsening cases of HAVS under RIDDOR

In respect of prosecution or enforcement action, this document states that "prosecution should be considered when there is a single case of HAVS stage 2 late or stage 3, or multiple cases of HAVS stage 1 and stage 2 early and late, AND there are/ were exposures regularly at/ above the EAV that are / were not controlled and managed SFAIRP to prevent harm". CTS is regarded as a significant health effect but reports of CTS alone should not normally result in prosecution. Guidance is provided for industry-specific good practice in appendix 6 for the following sectors:

- Foundries (Table 1A);
- Heavy Fabrication (Table 1B);
- Construction (Table 1C); and
- General management of HAV risks (Table 2)

APPENDIX A
CLINICAL AUDIT RECORD KEEPING TOOL

Name of doctor/nurse:	
Name of auditor:	
Date of audit:	

Instructions for completing the checklist:

Please tick the appropriate box, and (if required) please add comments in allocated box.

Do not write in the shaded areas.

No.	Question	Yes	No	N/A	Comment
1	Were the previous notes present at time of the assessment?				
2	Assessment of folder/electronic file to procedural standard:				
2.1	Is there a record of the subject's surname?				
2.2	Does it have the subject's first name?				
2.3	Does it have the subject's date of birth?				
2.4	Does it have identification of department?				
2.5	Are the continuation sheets, if any, tagged?				
2.6	Is the correspondence in chronological order?				
3.1	Is there a copy of the HAVs report in the notes?				
3.2	Does the report have the subject's DOB?				
3.3	Does the report have the subject's name?				
3.4	Does the report have the subject's address?				
3.5	Does the report have the subject's occupation?				
4.1	Is there a record of when the subject was seen and where?				
4.2	Does the report have the reason for attendance?				
4.3	Does it state the subject is fit to work with continued exposure to vibration tools with or without adjustments?				
4.4	Does it state the subject is fit to work in their substantive job role?				
5.1	Does the report refer to the Equality Act with reasoning?				
5.2	Does the report refer to current or recent level of daily vibration exposure?				
5.3	Is a Hand Arm Vibration Syndrome (HAVs) or Carpal Tunnel Syndrome (CTS) diagnosis supported?				

5.4	Staging stated as per HSE guidance?				
5.5	Has advice to employer about RIDDOR for HAVs / CTS been considered?				
5.6	Is there advice about future exposure? E.g. advised to reduce exposure as far as practicable or to below 100 HS points?				
5.7	Recommendation for further assessment?				
5.8	Review period clear?				
5.9	Has the subject of the report been copied into the report?				
5.10	Has consent been gained to send the report?				
6	Can the decision on fitness be justified?				
7	Is the overall impression one of good clinical management?				
8	**Are clinical notes:**				
8.1	Legible?				
8.2	Is there acknowledgement that a risk assessment has been carried out by the employer?				
8.3	Do the notes record the presenting complaint? E.g. blanching, tingling, numbness?				
8.4	Do the notes record family history?				
8.5	Do the notes record past medical history?				
8.6	Do the notes refer to daily vibration exposure?				
8.7	Do the notes record medication history?				
8.8	Do the notes record social history e.g. smoking?				
8.9	Do the notes record work history?				
8.10	Has the subject had the appropriate examination? E.g. Appearance, Circulation, Nervous system, Musculoskeletal.				
8.11	Has blanching been witnessed, or photographs received or requested?				
8.12	Are consent/confidentiality guidelines followed?				
8.13	Is there a clear impression?				
8.14	Is there a plan in place?				
8.15	Signed and Dated				
9	Any other special circumstances? Please give details.				
10	Could you manage this subject with these notes / report for this problem at next review?				

Auditor's Signature:

Date:

APPENDIX B
APPOINTMENT LETTER TEMPLATE

Patient Address

Clinic Address

Date

Dear

1. Find enclosed a questionnaire relating to your previous exposure to vibration. It is essential that you complete this with as much detail as possible and bring it to your appointment.

2. If you are taking regular medication, please bring along a list detailing your current prescriptions.

3. If you experience episodes of whiteness, tingling or numbness in your fingers or hands please use the enclosed hand pictogram form to shade in the affected area on the blank pictures of hands. If you have symptoms at night have this form ready to complete at the time rather than draw from memory in the morning.

4. If you experience episodes of finger whiteness it is very important that you bring along photographs to show the whiteness. A phone camera image is acceptable, and a printed copy would also be helpful. It is preferable that these photographs are taken with your hands alongside your face, one to show the fronts and another to show the backs of the hands.

5. Please ensure you do not work with vibrating tools on the day of the tests. Also, do not drink alcohol for 12 hours, or drink a caffeine containing drink for four hours, or smoke for three hours before testing.

Yours sincerely,

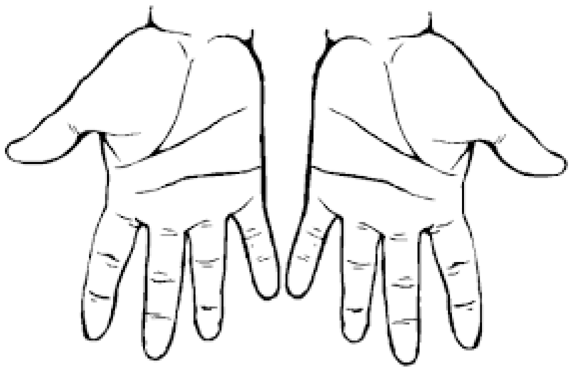
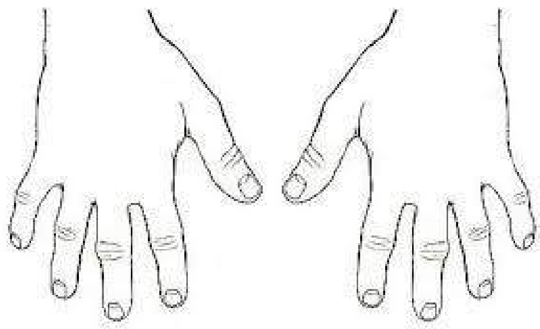
APPENDIX C
HAND PICTOGRAMS

Name	Date of Birth

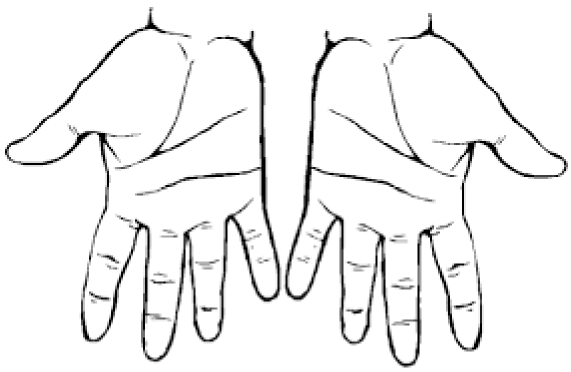
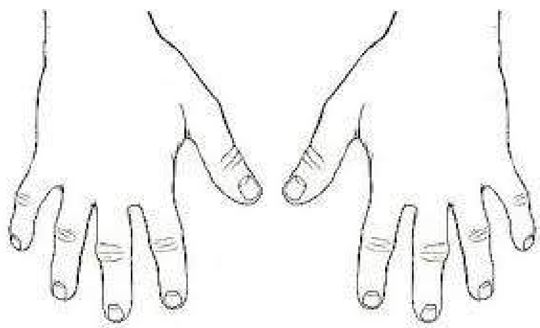
How to complete the pictograms

Shade in the areas on the illustrations below where you experience the relevant symptoms.

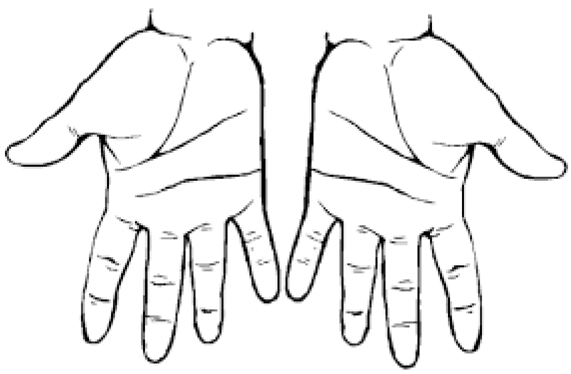
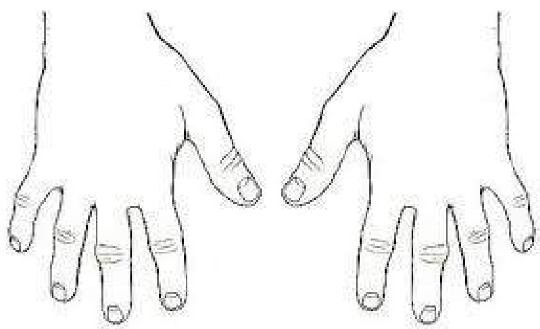
1. Whiteness

2. Tingling / Pins and needles

3. Numbness or loss of feeling

APPENDIX D
THE HAVS CONSULTATION CHECKLIST

Dr Minha Rajput-Ray, Dr Roger Cooke (June 2019)

Please note: This section is intended as a checklist/ aide memoire and should be read in conjunction with the other papers in this document

Background information and History Taking

1. Important to obtain as much as possible e.g. previous medical records, reason for consultation ?
2. Take into consideration the complexity of the assessment – is this for health surveillance, a legal opinion or a second opinion ?
3. Be aware of reinforcement of responses to questions regarding symptoms as the employee sees more healthcare professionals and the potential for this to influence the answers provided in the history taking.
4. Check with the employee for the availability of photographs of any colour changes reported, ideally correlating hand to the face to verify identity of the employee.

Exposure

1. HSE Guidance is that copies of risk assessments should be available to occupational health providers (ref: HSE Topic Inspection Pack Hand Arm Vibration Syndrome 2010)
2. In the absence of a copy of the risk assessment, time should be taken to find out as much as possible about the exposure - measured in metres per second, squared over an 8-hour period A(8), or using the HSE points system
   - The generally accepted "no harm level" is 1m/sec^2 (16 points on HSE Scale)
   - Daily exposure action value (EAV) of 2.5m/sec^2 (100 points on HSE Scale) indicates clear risk to the exposed employee requiring health surveillance and other actions by employer (e.g. provision of information, instruction and training).
   - Daily exposure limit value (ELV) at 5m/sec^2 (400 points on HSE scale) represents a high risk above which employees should not be exposed.
3. A site visit would be ideal and would represent best practice and is often worthwhile to see the tools used; alternatively a photograph of the workplace and tools would be a useful guide.

Handheld Power Tools	Hand Guided Machinery	Handheld Machinery	Others
• Fettling tools • Needle guns • Pneumatic flanging • Impact wrenches • Nibblers • Riveting tools • Nut runners • Hammer Drills • Jack hammers • Chipping hammers • Rammers • Percussive chisels	• Handheld polishers • Pedestal grinders • Rotary burring tools • Flexi driven grinders and polishers	• Lawn mowers • Chain saws • Brush straws • Barking machines • Strimmers • Hedge trimmers	• Shoe pounding up machines • Motorcycle handlebars

4. Access to the employer Health and Safety paperwork regarding use and whether there is regular maintenance of tools.
5. Use of the HSE Hand Arm Vibration Exposure Calculator
6. Remember to ask about exposure to cold (e.g. cold tool surface, cold air) and wet environments
7. Enquire about the use of protective equipment e.g. gloves. Useful to ask about perception of use of PPE – and whether there is good compliance with use.

The following is a summary chart when asking about types of tools used, which may be divided into four categories: Hand Held, Hand Guided, Hand Fed and others.

Risk Assessment

1. Risk assessment is a dynamic process.
2. Ask about measures that have been implemented to reduce the vibration and/or cold/wet exposure.
3. This is especially important in cases where there is suspected progression of symptoms.
4. It may be useful to construct a timeline, as this will help guide the risk assessment process.
5. Ask about modification to equipment, purchase of different equipment, overall maintenance of tools, job and/ task rotation
6. Where it has not been possible to control the exposure to vibration and associated factors, enquire about the use of a Health Surveillance Programme

Key points for Vascular changes

As far as possible, ensure open ended questions regarding changes in the initial distribution and current distribution. This is likely to be especially important with reference to the features below and when considering differential diagnoses that may occur in other conditions.

- distribution
- duration
- frequency
- provocative factors (eg cold, posture)
- reversibility – does the subject do anything to alleviate the symptoms (eg flick sign in CTS, change neck posture in cervical spondylosis)

Key points for Sensorineural changes:

As far as possible, ensure open ended questions regarding changes in sensorineural symptoms and reversibility upon cessation of tool use. Tingling for more than 20 minutes after tool use is a useful guide rather than a hard and fast rule for indication of pathological change. Sensory symptoms may be of tingling, numbness, anaesthesia hyperaesthesia or pain. It is important to record the subject's description of the nature of any sensory symptoms as well as

- distribution
- duration
- frequency
- provocative factors (eg cold, posture)
- reversibility – does the subject do anything to alleviate the symptoms (eg flick sign in CTS, change neck posture in cervical spondylosis)

Pay special attention to distribution of symptoms that may point to the pattern below and may also overlap with other upper limb musculoskeletal conditions:

- peripheral neuropathy
- nerve trunk lesion
- central lesion

Functional Ability

1. It is important to take a careful history of activities that require a level of manual dexterity. For example getting dressed (buttons, zips, shoelaces), lawn maintenance, fishing, snow or ice removal, washing the car, doing the dishes.
2. Ask specifically about out of work activities, including other part time work and hobbies.
3. Check if any modifications have been made to tools used at home for leisure pursuits, e.g. bubble wrap on the handle of a garden lawn mower.

General Observations

1. A general overview of how the employee behaves, managing buttons and shoelaces when undressing and dressing. Can they grip the door handle, manage buttons or shoelaces, complete the consent form?
2. An awareness of cooperation and bias (examiner, intra examiner based), being aware of the possibility of employee fatigue

Clinical Testing

1. Use of appropriately calibrated equipment as per good medical practice.
2. Remember to keep an open mind about other neuropathies that can affect the upper limb.
3. Many tests are subjective, and variable results may be obtained by the same examiner and/ or between different examiners - hence important to look at the picture as a whole.
4. It may be helpful to use a washable marker to ask the employee to 'draw on their hands' the area of tingling or numbness or other altered sensation.

Further Management

1. Having reconciled all the background information, history findings and clinical examination, there is likely to be benefit in reflecting on the case as a whole.
2. In cases of doubt, or concern seek opinion of a senior colleague with experience in HAVS. However, it is important to recognise that in HAVS many conclusions are based on subjective assessments, and opinion, and that opinions may differ amongst different clinicians.
3. In the case of HAVS related symptoms, outline a robust plan regarding Tier 5 testing or other further investigation. Ensure clarity as to what additional information this may provide to assist with diagnosis, staging or management?
4. Explain the above to the employee and obtain relevant consent to communicate this to the employer regarding further vibration and associated factor(s) exposure.
5. Advise the employee to report to his/ her supervisor immediately any change in upper limb symptoms.

REFERENCES

Budd D, Holness DL, House R Occup Med (Lond) 2018 Sep 13; 68(7):476-481 Functional Limitations in workers with hand-arm vibration syndrome (HAVS).

APPENDIX E
SUBJECT/EMPLOYEE INFORMATION LEAFLET

Revised version by Miss Nikla Rai & Professor Jill Belch, 2020

This Information Leaflet is for employees who work with vibrating tools.

Introduction

Hand-arm vibration syndrome (sometimes abbreviated to HAVS) is where excessive vibration exposure causes changes in the small blood vessels, usually of the fingers, and causes them to constrict (vasospasm) on exposure to cold and pressure (eg carrying a shopping bag). This spasm causes the fingers to go white (blanch), sometimes blue, and then, as the spasm is relived, and the blood returns, a red colour can be seen as the blood flow returns (reactive hyperaemia). The blanching can be accompanied by pain, and the redness accompanied by burning or tingling. HAVS is a form of Raynaud's phenomenon, Raynaud's has lots of causes, and excessive vibration exposure is just one of them.

There can also be changes in feeling (sensation) in the fingers. There are two types of sensation problems. The first is associated with the blanching, when numbness occurs, and the sensation returns when the blood flow returns. The second is where the small nerves, usually in the fingers, are damaged by vibration. This means that items held are not felt properly, so clumsiness can be a complaint, or of dropping things. It can cause difficulty with fine movements such as picking up coins and doing up buttons.

Causes of hand-arm vibration

As mentioned above repeated and frequent use of hand-held vibrating tools causes injury to the small nerves and blood vessels in the fingers. The injury is a result of holding the hand-held power tools (such as grinders, sanders, grinders, disc cutters, hammer drills, chipping hammers, chain saws, brush cutters, hedge trimmers, scrabblers, needle guns or road breakers), hand-guided equipment (such as powered lawnmowers or pedestrian controlled floor saws), or by holding materials being worked by hand-fed machines (such as pedestal grinders or forge hammers). Too much exposure to hand-arm vibration can cause Hand Arm Vibration Syndrome (HAVS) and Carpal Tunnel Syndrome. It would be unusual to develop hand-arm vibration syndrome unless vibrating tools had been used for some time.

What is Hand Arm Vibration Syndrome?

- HAVS affects the nerves, blood vessels, muscles and joints of the hand, wrist and arm.
- It can become severely disabling if ignored.
- It includes vibration white finger, which can cause severe pain in the affected fingers.

What is Carpal Tunnel Syndrome?

Carpal tunnel syndrome is a nerve disorder which may involve pain, tingling, numbness and weakness in parts of the hand, and can be caused by, among other things, exposure to vibration.

What are the early signs and symptoms to look out for?

- Tingling and numbness in the fingers (which can cause sleep disturbance).
- Not being able to feel things with your fingers.
- Loss of strength in your hands (you may be less able to pick up or hold heavy objects).
- In the cold and wet, the tips of your fingers going white then red and being painful on recovery (vibration white finger). If you continue to use high vibration tools these symptoms will probably get worse, for example:
- The numbness in your hands could become permanent and you won't be able to feel things at all.
- You will have difficulty picking up small objects such as screws or nails;
- The vibration white finger could happen more frequently and affect more of your fingers.

As above the most frequent symptoms are of blanching, numbness and tingling. The blanching may be mild, just affecting some fingertips at first, but may spread if continued over-exposure to vibration continues. Cold weather, working outside, touching cold objects or cold water can bring on attacks. This is due to blood vessel constriction (spasm).

As above there are two types of sensation problems;

- Loss of feeling (numbness) occurs with the blanching, but this symptom disappears when the vasospasm goes, and blood flow is returned.
- The second form of loss of feeling can be progressive, starting with tingling then progressing to significant changes/ loss of sensation if over-exposure continues. it may become difficult to handle coins, screws, nails, threads, etc. In some cases, one finger is badly affected with other fingers only mildly affected. This second form of sensation problem is related to small nerve damage.

Symptoms may remain mild but if over-exposure to vibration occurs, they can progress. The vasospasm may affect more fingers, become more frequent, occur in warmer months as well as colder months, and the sensation problems may make carrying out daily living tasks difficult. These severe forms are, however, thankfully rare.

ADVISORY NOTE 1:

1. A daily EAV of 2.5 m/s^2 A(8) represents a clear risk requiring management; and
2. A daily ELV of 5 m/s^2 A(8) represents a high risk above which employees should not be exposed.

What the law says

- Make sure that risks from vibration are controlled
- Be provided with information, instruction and training are provided to you on the risk and the actions being taken to control risk
- Attend health Surveillance appointments
- Your employer has a duty to reduce the risks from vibration to the lowest level reasonably practicable and to reduce exposure to as low as reasonably practicable if it is above EAV (Exposure Action Value). Exposures should not exceed ELV (Exposure Limit Value).

How can Employees help reduce the risks?

It is your employer's responsibility to protect their employees against HAVS and carpal tunnel syndrome, but you should help by asking your employer if your job could be done in a different way without using vibrating tools and machines. If this cannot happen:

- Ask to use suitable low-vibration tools.
- Always use the right tool for each job (to do the job more quickly and expose you to less hand-arm vibration).
- Check tools before using them to make sure they have been properly maintained and repaired to avoid increased vibration caused by faults or general wear.
- Make sure cutting tools are kept sharp so that they remain efficient.
- Reduce the amount of time you use a tool in one go, by doing other jobs in between.
- Avoid gripping or forcing a tool or workpiece more than you have to.
- Store tools so that they do not have very cold handles when next used.
- Encourage good blood circulation by:
  - keeping warm and dry (when necessary, wear gloves, a hat, waterproofs and use heating pads if available);
  - giving up or cutting down on smoking because smoking reduces blood flow; and - massaging and exercising your fingers during work breaks.

ADVISORY NOTE 2:

Stopping or reducing working with vibrating tools may prevent symptoms from becoming worse if enacted early enough. In general, you can reduce risks of vibration exposure by either reducing the vibration transmitted to your hand or by reducing the time-spent holding vibrating equipment or workpieces.

How to avoid HAVS

- Learn to recognize the early signs and symptoms of HAVS.
- Report any symptoms promptly to your employer or the person who does your health checks.
- Use any control measures your employer has put in place to reduce the risk of HAVS.
- Ask your trade union safety representative or employee representative for advice.
- Discuss any concerns with your employer/occupational health team
- Keep warm at work, especially the hands
- Do not smoke as the chemicals in smoke cause vasospasm
- If your tools are marked with time limits, obey these
- Take regular breaks away from the tools. Short bursts of exposure are better than one long exposure
- Ensure tools are well maintained.

Management of HAVS in workplaces:

If symptoms occur these should be reported to your employer, who may well already be screening for HAVS every year through a questionnaire. They will refer you for assessment to occupational health. The results will be discussed with you and an action plan devised.

During the assessment other causes for symptoms will be looked at, for example some drugs can cause vasospasm. Non-drug 'treatments' such as wearing gloves, using hand warmers etc can be useful. Also stopping smoking will be encouraged.

HAVS, when mild or moderate, can get better when vibrating machine use is reduced or stopped. Unfortunately, when severe it may persist even when vibration exposure has ceased.

ADVISORY NOTE 3:

In some workplaces there are already information available to show the operating time of equipment so that daily exposure action values are not exceeded. Please ensure you are aware of your Organisation's guidance.

REFERENCES

For more information on hand-arm vibration, see HSE's free leaflet Control the risks from hand-arm vibration INDG175 (rev2) and Hand-arm vibration INDG296 (rev 2) and visit HSE's vibration website at www.hse.gov.uk/vibration

APPENDIX F
REPORT TEMPLATE TIER 3 ASSESSMENT

Dr Roger Cooke, June 2019

1. The following report template is intended for guidance to those undertaking Tier 3 surveillance in accordance with the Control of Vibration at Work Regulations.
2. There are 4 options available as follows, with introduction and conclusion paragraphs, but as each case will vary in presentation, this can only be used as a basis for any report and is intended to assist in ensuring that all relevant issues are reported to the employer. Free text should be added as required to ensure appropriate advice is offered to the employer.

Manager name
Company Name
Company Address

Date
Dear

Re: Employee name

Thank you for asking me to see Mr/Ms ____________ which I did today at ___________ . This was for the purpose of tier 3 assessment in accordance with the Control of Vibration at Work regulations (2005), which is required to assess whether or not an employee has symptoms compatible with a diagnosis of either hand arm vibration syndrome (HAVS) or carpal tunnel syndrome (CTS). Mr/Ms ____________ had previous completed a tier 1 OR tier 2 questionnaire and was referred for tier 3 assessment as a result of issues declared on that.

I note that this was the first tier 3 assessment s/he has undergone OR he last had a tier 3 assessment on ____________

I understand that s/he has / has not previously been diagnosed with HAVS/ CTS.

S/he tells me that s/he has not previously been involved in any litigation relating to HAVS or CTS OR he has previously had a common law claim for HAVS/ CTS.

OPTION 1

This tier 3 assessment did not reveal any symptoms compatible with HAVS or CTS. No further health assessment is required at this stage, but further routine health surveillance should be undertaken in accordance with the findings of your vibration risk assessment.

OPTION 2

This tier 3 assessment identified symptoms compatible with HAVS or CTS, and further assessment is required in accordance with the Control of Vibration at Work regulations 2005. I recommend referral to an occupational physician for that. While the outcome of that assessment is awaited, I recommend that Mr/Ms ____________ is fit to continue in his/her current role, but that you should ensure any exposure to vibration is reduced to as low as reasonably practicable.

OPTION 3

This tier 3 assessment identified symptoms compatible with HAVS or CTS, and further assessment is required in accordance with the Control of Vibration at Work regulations 2005. I recommend referral to an occupational physician for that. While the outcome of that assessment is awaited, I recommend that Mr/Ms ____________ should avoid any further exposure to hand transmitted vibration.

OPTION 4

This tier 3 assessment did not identify symptoms compatible with HAVS or CTS but did identify the presence of another condition that requires further assessment. I recommend referral to an occupational physician for that. Meanwhile, Mr/Ms ____________ is fit to continue in his current role, but you should ensure his exposure to vibration is reduced to as low as reasonably practicable in accordance with the Control of Vibration at Work regulations.

It should be noted that tier 3 assessment does not constitute a formal diagnosis.
No obligations arise in respect of reporting under RIDDOR as a result of this assessment.

Mr/Ms ____________ has been advised of my opinion, and the reason for the advice offered. I confirm that s/he is aware that I am reporting in these terms, and s/he has consented to release of this report, on the basis that s/he receives a copy at the same time as OR before it is sent to his/her manager OR without receiving a copy him/herself.

Yours sincerely

APPENDIX G
REPORT TEMPLATE TIER 4 ASSESSMENT

Dr Roger Cooke, June 2019

The following report template is intended for guidance to those undertaking Tier 4 surveillance in accordance with the Control of Vibration at Work Regulations.

1. As each case will vary in presentation, severity, work exposure etc, this can only be used as a basis for any report and is intended to assist in ensuring that all relevant issues are reported to the employer. Free text should be added as required to ensure appropriate advice is offered to the employer.
2. There are a number of sections with options available as follows:
   a. The introduction contains options regarding previous surveillance, previous diagnosis and previous litigation.
   b. Section 1 has five options A-E re diagnosis
   c. Optional paragraph 2 refers to RIDDOR reportability
   d. Section 3 gives four options A-D re further exposure
   e. Section 4 – two options re fitness for work
   f. Section 5 – two options re Equality Act
4. The scope of the Equality Act is continually developing, and while it is evident that stage 3sn HAVS is likely to produce significant day-to-day functional impairment, it is less clear whether 2sn or episodes of Raynaud's phenomenon would be regarded as doing so. We are not aware of this having been tested at law.

Manager name
Company Name
Company Address
Date

Dear

Re: Employee name

Thank you for asking me to see Mr/Ms _____________ which I did today at __________ . This was for the purpose of tier 4 (physician) assessment in accordance with the Control of Vibration at Work regulations (2005).

I note that this was the first tier 4 assessment s/he has undergone last had a Tier 4 assessment on __________ when it was concluded that s/he had carpal tunnel syndrome CTS / had Hand Arm Vibration Syndrome at stage x / did not have Hand Arm Vibration Syndrome or Carpal Tunnel Syndrome.

S/he tells me that he has not previously been involved in any litigation relating to HAVS or CTS. OR S/he has previously had a successful common law claim for HAVS.

CURRENT AND PREVIOUS EMPLOYMENT

I understand that since (date), Mr/Ms _____________ has worked as a (job title), using tools as listed below.

Tools used	Date of exposure		Average daily hrs trigger time	Average days per week
	From	To		

S/he reports no other exposure. OR S/he reports significant exposure to vibration prior to the current employment, as listed below:

S/he describes no significant non-occupational exposure to vibration OR S/he reports non-occupational exposure to vibration as a result of ___________

1. DIAGNOSIS

This diagnosis is based upon the symptoms reported by (employee name), and consideration of other information provided, being ________________

Clinical examination revealed:

OPTION 1A NOT HAVS

In my opinion s/he does not have Hand Arm Vibration Syndrome (HAVS) or Carpal Tunnel Syndrome (CTS).
S/he remains fit to continue in his/her present role. Further surveillance is recommended in accordance with your risk assessment regarding continuing exposure to hand transmitted vibration.

OPTION 1B - NOT HAVS - ANOTHER CONDITION

In my opinion s/he does not have Hand Arm Vibration Syndrome (HAVS) or Carpal Tunnel Syndrome (CTS), but does have (condition). S/he remains fit to continue in his present role. (Insert advice re: other condition). Further surveillance is recommended in accordance with your risk assessment regarding continuing exposure to hand transmitted vibration.

OPTION 1C – HAVS

S/he now reports symptoms, which, in my opinion, are those of Hand Arm Vibration Syndrome at stage R v sn L v sn. This represents mild / moderate / severe symptoms of this condition. These symptoms were first noticed during the current employment / during previous employment.

OPTION 1D – possible CTS

S/he reports symptoms suggestive of carpal tunnel syndrome (CTS), which is likely to be related to (use of handheld vibratory tools) (and) (ergonomic factors associated with wrist posture). There is (also) (no) evidence that this is related to factors other than work. I have advised him/her that this requires further investigation, and recommended that s/he contact his/her GP, with a copy of this letter. I have also offered him/her advice to improve the symptoms. Until the investigations are complete, s/he is fit to continue his current role OR s/he should avoid the use of handheld vibratory tools OR use of handheld vibratory tools should be reduced so far as is reasonably practicable but, in any case, limited to no more than 2.5 m/sec^2 daily A(8), or 100 points on the HSE scale. I recommend review of the risk assessment of his /her vibration exposure, and of his/her wrist and hand movements in accordance with the Manual Handling regulations.

OPTION 1E – diagnosed CTS

S/he reports symptoms that are diagnostic of carpal tunnel syndrome (CTS), that is likely to be related to (use of handheld vibratory tools) (and) (ergonomic factors associated with wrist posture). There is (also) (no) evidence that this is related to factors other than work. (S/he has had nerve conduction studies confirming the diagnosis). S/he (is fit to continue his current role) (should avoid the use of handheld vibratory tools) (use of handheld vibratory tools should be limited to no more than 2.5 m/sec^2 daily A(8), or 100 points on the HSE scale). I recommend review of the risk assessment of his/her vibration exposure, and of his/her wrist and hand movements in accordance with the Manual Handling regulations.

In my opinion, further clinical assessment is / is not required to confirm this diagnosis / staging.

Other relevant conditions

I note that Mr/Ms ___________ has no other relevant medical condition OR also has ________________

2. REPORTING OF INJURIES, DISEASES AND DANGEROUS OCCURRENCES REGULATIONS (RIDDOR)

OPTION 2A

As there is no diagnosis of a condition specified within RIDDOR, no action is required in this respect

OPTION 2 B

As this is the first formal diagnosis, and assuming that the exposure criteria are met, the condition is reportable under RIDDOR. I would recommend formal review of your risk assessment of his exposure to hand transmitted vibration.

OPTION 2C

This diagnosis requires reporting under RIDDOR, but the symptoms are not new and do not appear to show significant deterioration. Hence, if the condition was previously reported, no further action is required.

3. RECOMMENDATIONS REGARDING FUTURE EXPOSURE TO VIBRATION

OPTION 3A

Although Mr/Ms ____________ (name) is currently symptom free, it remains important that his/her exposure to hand transmitted vibration is reduced so far as is reasonably practicable, in accordance with regulatory requirements

OPTION 3B

In order to minimise the risk of deterioration of symptoms, I recommend that his/her future exposure to hand transmitted vibration should be reduced so far as is reasonably practicable, but in any case, to less than 2.5 m/sec2 daily A(8), which is 100 points on the HSE scale.

OPTION 3C

He reports little continuing exposure. If that is correct, which should be confirmed by formal review of the relevant risk assessment, no further action is required.

OPTION 3D

The severity and nature of his/her symptoms is such that I recommend he cease using handheld vibratory tools forthwith.

4. FITNESS FOR WORK

OPTION 4A

In other respects Mr/Ms ____________ remains fit for his current role.

OPTION 4B

Because of the symptoms described Mr/Ms ____________ should be considered unfit to continue in his/her present role. S/he is fit for tasks other than (insert recommended limitations)

5. EQUALITY ACT

OPTION 5A

It is my opinion that the symptoms are not likely to cause significant functional impairment in day-to-day activities, and hence that the Equality Act is not likely to apply. You will be aware however that determination of this requires an assessment by the employer based on medical advice.

OPTION 5B

It is my opinion that the sensory symptoms, being at the severe end of the spectrum, are likely to cause significant functional impairment in day-to-day activities. I would therefore recommend that you undertake a formal assessment in respect of the Equality Act, which seems likely to apply.

Mr/Ms ____________ has been advised of my opinion, including diagnosis, the clinical staging and the above recommendations. S/he is aware that it is a managerial role to consider their implementation.

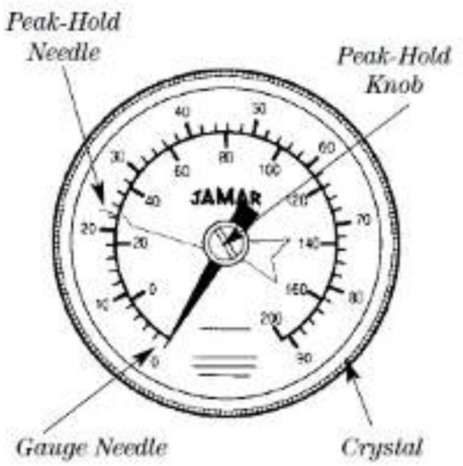
I confirm that he is aware that I am reporting in these terms, and s/he has consented to release of this report, on the basis that s/he receives a copy at the same time as OR before it is sent to his/her manager OR without receiving a copy him/herself.

Yours sincerely,

APPENDIX H
DETAILED PROCEDURE FOR CHECKING DYNAMOMETER

To check the posts:

Remove the adjustable handle. Check that each post moves freely in its guide (the plastic section where the posts attach to the main unit). There should be a little bit of movement and the posts should wiggle slightly; they should be loose in their guides, even when you put pressure on the sides of the post.



To check the hydraulics:

Remove the adjustable handle. Whilst watching the top post, push the bottom post inwards. When you do this, the top post will move in the opposite direction. Then repeat on the other side, i.e., whilst watching the bottom post, push the top post inwards and the bottom post will move in the opposite direction. Normally both posts should travel approximately 1/8 inch (3mm), with top and bottom posts travelling in opposite directions. Travel less than 1/16 inch (1.5mm) means that the device requires servicing as it indicates a leak in the hydraulics system. You can measure this by holding a ruler by the guide whilst pushing on the opposite post and/or by enlisting the help of another researcher.

To check the handle:

Grasp the instrument normally and carefully look at the way the forks of the adjustable handle are supported on the posts. Each fork should touch the post approximately at its mid-point. If not, the instrument should be returned for adjustment.

To check the peak-hold (red) needle:

Turn the peak hold knob (figure 2) counter clockwise and check the peak-hold and gauge needle move without any excessive friction. If the peak-hold needle is not in-line with the gauge needle when it is set back to zero and/or if there feels to be excessive friction when doing so, then you should return the instrument for servicing.

Greasing:

About once a year, place a small amount of grease on the two guides. If excessive friction exists between the post and guide, return the dynamometer for servicing. If the peak-hold needle is knocked off its support pin, it can readily be repositioned. Unscrew the see-through crystal cover (figure 2) and turn it upside down. Locate the brass pin in the centre of the crystal (part of the chrome knob on the outside of the crystal). Locate the slot on the brass pin and place the peak-hold needle into this slot.

APPENDIX I
EXAMPLES OF HANDHELD VIBRATING TOOLS

Collated by Nikla Rai 2020


Vibrating Wacker Plate


Jack hammer


Drills


Broachers


Floor saws


Rammers


Vibrating rollers


Boring equipment


Masonry cutters


Floor tile remover


Concrete cleaners / needle scalers


Concrete plane


Floor grinders


Floor tile stripper


Metal cutters


Floor polishers


Wood Planes


Timber/Chain Saws


Wood Sanding machines


Metal Grinders


Masonry Sanding machines


Air guns


Hedge Cutters and Strimmers


Lawn Mowers

Electric screwdrivers

Electric Impact wrenches

Shot blasters and
pressure washers

Riveters

Lab Vortex machines

Shoe making machine

Motorcycle handlebars

APPENDIX J
PEER SUPPORT REQUEST TEMPLATE

Supporting occupational health and wellbeing professionals

Following a series of meetings of the SOM Special Interest Group in HAVS it was decided to offer a system of support for members of the SOM who are undertaking HAVS assessments and require support or advice from a senior colleague with more experience in the subject. We aim to respond to queries within 14 days.

Is your query relating to L140 or other HSE documentation? Yes ☐ No ☐

If no, please state below. If yes, please contact the HSE directly

....

If your query relates to advice on medical conditions or differential diagnosis, please state below:

....

If your query relates to equipment for HAVS testing, please state below.

....

If your query relates to HAVS Assessment process, please tick as relevant and explain below.

1. HAVS 1 ☐
2. HAVS 2 ☐
3. HAVS 3 ☐
4. HAVS 4 ☐
5. HAVS 5 ☐

....

If your query relates to staging, please state below.

....

PLEASE SUBMIT THE COMPLETED FORM TO admin@som.org.uk

APPENDIX K
NERVE CONDUCTION STUDIES IN WORKERS EXPOSED TO HAND-TRANSMITTED VIBRATION

Background

The referral for Nerve Conduction Studies (NCS) as part of health surveillance has both cost and time implications and is not generally regarded as part of routine health surveillance of vibration exposed employees. However the role of NCS in the assessment of employees exposed to HTV has both potential benefits and drawbacks.

In addition, whilst NCS can assist in the diagnosis, grading and differential diagnosis of suspected CTS not all clinicians support this utility.[1, 2, 3] Studies by Lew and Atroshi suggest that NCS has a sensitivity of about 75%.[4, 5] Edwards and Frampton deployed a six domain questionnaire to identify those scoring above a predetermined CTS 'threshold' and demonstrated a reduction in the need for NCS by nearly 50% with a significant potential cost saving.[6] Violante noted that epidemiological studies of occupational CTS often report asymptomatics with electrophysiological evidence of median neuropathy and many symptomatics that did not.[7]

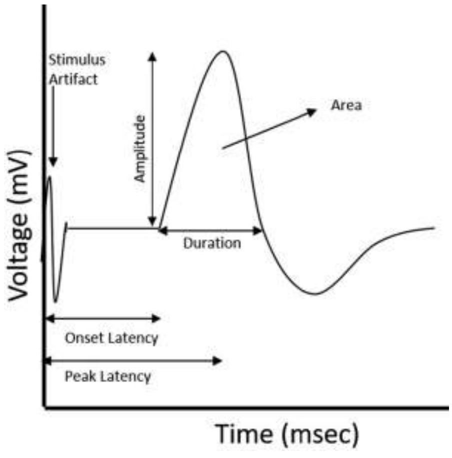
Notwithstanding these caveats, atypical clinical cases do arise and the likelihood of CTS may need to be ruled in, or ruled out, given the multiple clinical end points that can arise following exposure to HTV e.g. vascular and sensory HAVS, CTS or co-morbid combinations of compressive neuropathies.[8]

Basic Guide to Nerve Conduction Studies (NCS)

The peripheral nervous system transmits rapid impulses via myelinated motor and sensory nerve fibres which can be detected by measuring their action potentials. Slower conduction is via unmyelinated nerve fibres. The physiological direction of transmission e.g. in motor nerves towards a muscle and in sensory nerves towards the spinal cord is referred to as orthodromic. In nerve conduction studies an electrical stimulus applied to a nerve containing both motor and sensory fibres can fire in both directions, orthodromic and antidromic (opposite of physiological) and then measured by suitably placed surface electrodes.

Orthodromic motor responses are referred to as compound muscle action potentials (CMAP) and antidromic as F-waves thus providing information about the distal and proximal portions of motor nerves. Sensory conduction is usually recorded by an antidromic electrode placed over the distribution of the cutaneous nerve under test giving rise to a sensory nerve action potential (SNAP). Whilst there are various conventions on placement and distance of recording electrodes, the resulting recordings allow for the measurement of a latency period (DSL; distal sensory latency, DML; distal motor latency) prior to an action potential (see Figure 1) and along with distance travelled by an impulse allows the calculation of a conduction velocity (CV).

Figure 1: Action potential (DaSilva et al)[9]



Whilst numerous other values may be reported in neurophysiology reports these provide the mainstay of interpretation and are sufficient for understanding by the occupational health practitioner.

Neuropathology and nerve injuries: definitions

Neurapraxia

A mild nerve compression such as nerve injury or acute entrapment neuropathy leading to demyelination with remyelination usually occurring in days to weeks. This can have an initial impact on conduction velocity and distal latencies.

Axonotmesis

More severe and prolonged compression leads to damage to the distal nerve axon with poorer likelihood of recovery or taking months. This can cause reduced or absent amplitudes along with slowing conduction velocities and latencies. Complete disruption to axons is called neurotmesis.

Other considerations

Diffuse polyneuropathies may show features of both myelin and axon damage in NCS results. Also, there is often a combination of myelinopathy and axonopathy with more severe nerve entrapments and as such results of specific NCS metrics can help classify cases into mild, moderate and severe (see section on interpretation and severity).

Finally, it should be noted that standard NCS tests the larger diameter and fastest conducting sensory fibres which comprise only 20% of the whole nerve and as such do not help to exclude a peripheral receptor level neuropathy such as occurs in HAVS.[10] There is some limited evidence to suggest smaller diameter fibres may also damaged in severe CTS.[11,12]

Nerve Conduction Studies in vibration-exposed workers

Where fractionated nerve conduction velocity has been performed on symptomatic vibration-exposed subjects a bimodal distribution of nerve conduction velocity was found pointing to effects at both the level of the carpal tunnel and more distally at palmar or finger level.[13] Other studies have found delayed sensory nerve conduction in the digits.[14,15] By contrast, the study by Lander et al using standard NCS demonstrated that the predominant neurological abnormality identified in workers using vibrating tools were neuropathies of the ulnar and median nerve that were proximal to the hand.[16] This contrasts with an earlier study using fractionated antidromic NCS of digital, digital to palm, palm to wrist and wrist to elbow segment sensory nerve conduction velocity of median nerve (n =56 controls 43).[17] The study showed slowing across both carpal tunnel (wrist to palm) and digital segments with the slowing in the digital segment correlating with late stage HAVS (Stockholm sensorineural: stage 0SN 10% and 56% 3SN). Fractionated NCS is usually not available to the occupational health practitioner, but this type of multilevel testing has the potential to play a future role in both differential diagnosis and staging of HAVS.

The limitation of standard NCS alone for detecting the site of injury, either because of the variety of diameters in sensory nerve fibres that pass through the carpal tunnel, or because the injury is in the more distal smaller fibres and receptors in the palms and fingers, suggests it has little value in the routine surveillance of vibration exposed. Sanden et al followed up a vibration exposed cohort of manual workers and controls over 21 years and found no exposure response relationship and concluded that NCS may not be a sensitive method for detecting smaller vibration-related pathological changes.[18] Giannini et al summarised the dilemma succinctly following an electrophysiological study of forestry workers as 'vibration-induced neural involvement can be considered neither pure digital neuropathy, nor definite CTS'.[19] Therefore where there is a clinical suspicion of CTS in vibration exposed there is a case for recommending both standard NCS and receptor level QST, particularly when CTS, if found is usually amenable to treatment.[20] In addition, a diagnosis of the dual pathology of CTS and HAVS should only be made after full assessment and treatment of the CTS if present. In this case an assessment of the stage HAVS has reached can at best be presumptive and only confirmed following the treatment of CTS.

Another benefit of targeted NCS in vibration exposed is the elimination of other proximal compressive neuropathies such as Cubital Tunnel Syndrome (CuTS) that may contribute to sensory symptoms in the hand. Cubital tunnel syndrome is the second commonest compressive neuropathy in the upper limb and should be discounted in vibration exposed who report nocturnal symptoms predominantly confined to the ulnar supplied fingers. It should be added here that epidemiological evidence for a causal attribution of CuTS to vibration is very limited. Karkosy et al investigated vibration exposed workers by neurophysiology and electromyography (n=167) and found a high prevalence of upper limb compressive neuropathies and found 42.5 per cent had CuTS.[21] Yet a further retrospective study by the same lead author[22] of 154 foundry workers using chipping hammers and grinders reported 41 cases of 'distal' type neuropathy and 21 cases of compressive neuropathy more consistent with the findings by Lander.[16]

Dasgupta et al found 23 cases of ulnar nerve neuropathy out of 66 jack hammer users in a questionnaire and motor nerve conduction study.[23] Sanden et al found no increased prevalence of ulnar nerve abnormalities.[18] Whilst the evidence base to support the case of working with hand held vibrating tools being a risk factor for CTS is significant, the equivalent evidence for other compressive neuropathies remains uncertain. In a recent study Ahmed et al found an overall higher prevalence of compressive neuropathies in patients examined for HAVS and concluded that NCS should be included in HAVS assessment (n= 431, 45% median neuropathy and 7% ulnar neuropathy) acknowledging that previous studies on ulnar neuropathy were comparable with non-exposed.[8]

One advantage of the addition of NCS in vibration exposed is in differentiating between the potential location of any neurological damage i.e. along the nerve trunk or at the receptor level.[24,25] The presentation of sensory symptoms in vibration exposed do not necessarily follow a typical pattern of either a regional entrapment or a peripheral neuropathy. For example, if the median or ulnar nerves are compressed at the wrist then vibrotactile thresholds (large myelinated fibres and mechanoreceptors), possibly cold thresholds (small myelinated fibres) and nerve conduction velocities may all be abnormal. However, if nerve conduction studies are normal but vibrotactile and thermal thresholds are abnormal, this points to the damage being at the receptor level. In this context the combination of NCS and sensorineural tests in a vibration exposed individual with sensory symptoms are more than just a test of severity but a tool of differential diagnoses supporting a diagnosis of HAVS.[25] Stromberg et al previously suggested that severe sensory HAVS was reflected in results of vibrotactile thresholds but not in neurophysiological results[26].

Point-of-Care Nerve Conduction Studies (POC NCS)

The advent of devices for point-of-care nerve conduction studies (POC NCS) offers a solution to the problem of time and costs in the health surveillance setting.[27] Various devices are commercially available (e.g. NEUROmetrix® ADVANCE™ and Mediracer®) which measure various neurophysiological parameters. To measure severity, it is preferable to choose a device that measures sensory and motor latencies with their amplitudes and has an F-wave functionality. Whilst having the same potential for false positives and negatives as conventional NCS their accuracy by comparison has been reviewed in a meta-analysis of median neuropathy concluding clinically relevant accuracy (n = 448, sensitivity 88%; specificity 93%).[28] However, the American Academy Orthopaedic Surgeons (AAOS) currently report only limited evidence in support of these hand-held devices.[29] Yet it has been shown that NCS when used in vibration exposed the prevalence of median and ulnar neuropathy proximal to the hand is greater than presumed by history and examination alone.[16] Descatha et al used POC NCS and found physical examination, either alone or combined with appropriate symptoms, did not sufficiently predict CTS in a working population (n=1108) and suggested using specific symptoms as a screening tool, and only NCS as confirmation.[30]

Referral Criteria

With the caveats outlined above a set of referral criteria has been devised.

1. Where there is doubt over differential diagnosis of sensory HAVS, CTS or CubTS.
2. Where the diagnosis is suggested by history but there is a reluctance to pursue treatment options or accept workplace restrictions or modifications.
3. To grade CTS and act as an adjunct to advice on workplace restrictions and inform recommendations for referral and treatment plans.

The National Institute for Health and Care Excellence (NICE) on CTS specialist assessment and management includes advise on NCS referral: https://cks.nice.org.uk/topics/carpal-tunnel-syndrome/management/management/

Interpretation of results

Whether conventional laboratory NCS or clinic POC NCS is carried out, the occupational health practitioner should have a rudimentary understanding of test results. Whilst neurophysiologist or test generated results are normally reported there are some key parameters that the practitioners should be aware of. In addition, the separation into mild, moderate or severe CTS is useful in the context of advising on the type of initial clinical management and interim advice on continuing exposure. Both motor conduction and the sensory conduction are required to distinguish CTS severity. Laboratories report against their normative data which can vary between centres depending on methodologies used (e.g. electrode positioning and distances measured including the direction orthodromic or antidromic).

Age, sex, height and weight can also influence results such that using standard reference tables can impact sensitivity and specificity.[31] For example, age can have a significant effect on conduction velocity which can vary from 50 m/s to 70m/s in adults declining after 40 years of age. As well electrode placements and distance measured, the size and temperature of the hand, the equipment used and recording techniques all impact the results (usual position for the active electrode in motor studies is the abductor pollicis brevis (APB) for median nerve and adductor digiti minimi (ADM) for ulnar nerve and for sensory studies digit 2/3 and digit 5 respectively and normally indicated on the report). Sometimes onset latency is reported and sometimes peak latency.

Comparison of symptomatic and contralateral hand and median ulnar differences can often be more useful than normal value tables. Therefore, the occupational health practitioner should always be mindful of the normative values of the reporting laboratory. With these caveats in mind, reproducing tables showing fixed normative values is therefore not appropriate for the purposes of this document other than to list some general adult upper limb by way of example to familiarise practitioners with the type and scale of values reported:[32]

SNAP: ≥ 20 µV*

DSL: peak median ≤ 3.5 ms; peak ulnar: ≤3.0 ms

CAMP: ≥ 5 mV

DML: median ≤ 4.2 ms; ulnar: ≤ 3 m/s

CV: ≥ 50 m/s

Median Ulnar Difference, MUD: (e.g. DSL ulnar subtracted from DSL median) ≤ 0.3 to 0.4 m/s

**For example, as well as individual factors laboratory norms may vary e.g. ≥ 10µV to ≥ 15µV and normative median nerve SNAPs are generally reported as higher than ulnar nerve e.g. AANEM 13µV and 9µV*

(AANEM data https://www.aanem.org/getdoc/9781edf5-f279-4c58-8a1b-24abc61a2c98/Electrodiagnostic-Reference-Values-for-Upper-and-L.aspx)

Severity scales and case management

Whilst CTS severity can be assessed clinically by staging symptom progression[33] without recourse to NCS, some severity scales based on NCS results have been developed. Padua et al in a prospective study in 500 hands with CTS symptoms categorised severity following neurophysiology: extreme CTS (absence of median motor, sensory responses), severe (absence of sensory response, abnormal Distal Motor Latency, DML), moderate (abnormal Sensory Nerve Conduction Velocity, SNCV, abnormal DML), mild (abnormal SNCV, normal DML).[34] A review of normative data used in electrophysiological categorisation systems for CTS and those used in POC NCS have been published.[35,36] Severity scales that incorporate symptoms with NCS results or ones that assist in treatment options have also been devised (Appendix 1).[37,38]

As stated, full neurophysiological testing can be expensive, time consuming and sometimes uncomfortable so a simpler method is to compare ring finger sensory latency (median and ulnar) referred to as the median ulnar difference (MUD) which has been shown to correlate with the severity of CTS[39]. Categorisation into severity may not however provide any longer term prognostic value following optimal surgical treatment.[40] The American Academy of Orthopaedic Surgeons (AAOS) has developed appropriate use criteria (AUC) for the management of CTS using a scoring system (Appendix 1) which has been found to be a practical tool in case management.[41]

The availability of these severity grading tools may assist not only with decisions on treatment options but act as an adjuvant on decision making regarding exposure. For example, with informed consent and an understating of potential risks, milder cases may be able to continue at work using vibrating tools with reduced exposure where feasible whilst awaiting investigations, whereas moderate to severe cases should avoid all vibration exposure until after investigation and treatment as appropriate. Irrespective of severity and attribution of compressive neuropathy in vibration exposed workers an awareness of the ergonomic risks inherent in the use of hand-vibrating tools should also be factored into the advice on workplace exposures.[42]

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Severity scales and AAOS appropriate use criteria AUC

Scale 1 (Sonoo et al)[38]

CTS Severity	Electrodiagnostic findings	Intervention
CTS without median neuropathy at the wrist (MNW)	None	Symptomatic treatment
Mild	Abnormality in comparison studies or median sensory nerve	Symptomatic treatment
Moderate	Prolonged distal motor latency to the abductor pollicis brevis with normal APB CMAP amplitude	Injections/surgery with progression
Severe	Above plus either reduced median to APB CMAP amplitude and/or abnormal needle EMG in the thenar muscles	Surgery if not contraindicated

Scale 2 (Szabo et al)[37]

Severity of CTS	Description & NCS
Stage 1	Transient epineural ischemic episodes cause intermittent pain and paresthesia in the median nerve's field in the hand. These symptoms typically occur at night or following specific activities such as driving a car or holding a book or newspaper, and suggest the presence of nerve transmission disorders.
Stage 2	Constant paresthesia and tingling, corresponding to disturbed intraneural and epineural microcirculation concomitant with intrafascicular oedema. Electrodiagnostic tests usually reveal abnormal sensory conduction.
Stage 3	Sensory and motor function are permanently damaged, and there is atrophy of the thenar eminence. Electrodiagnostic tests are abnormal, and demyelination and axonal degeneration secondary to prolonged endoneural oedema may be present.

Appropriate use criteria: carpal tunnel syndrome management.

https://www.orthoguidelines.org/go/auc/auc.cfm?auc_id=224989

APPENDIX L
VIBRATION-RELATED URTICARIA/ ANGIOEDEMA

Introduction

Urticaria is a dermal manifestation of a local allergic response, and is typically manifest by raised weals or hives, which are extremely itchy, developing within minutes of the relevant exposure, and typically resolving in 24 hours or less. Angioedema is swelling manifest by more generalised swelling of deeper layers of the skin, and both develops and resolves more slowly. Occupational urticaria has long been regarded as less common than irritant dermatitis or allergic eczema[1], accounting for 1-8% of reported cases of occupational skin disease[2].

While most commonly associated with allergy to materials such as latex, or animal or vegetable materials[3], urticaria is known to occur occupationally in response to physical stimuli such as heat or cold and is associated with release of histamine by degranulation of mast cells[4]. Examples of physical urticaria such as cold urticaria may be acquired or familial , when it has been shown to be related to genetic variants[6,7] and may require systemic as well as local cooling to provoke symptoms.

Vibration urticaria/ angioedema

Hereditary vibration angioedema and urticaria was first reported in 1972 . Since then an autosomal dominant trait has been shown to underlie some cases, with a genetic variant in ADGRE2, although the paper reporting this finding described urticaria also occurring in response to other stimulation of the skin, which sometimes produced typical pruritic hives, accompanied by facial flushing, headache or a metallic taste[9]. Hereditary vibratory angioedema is often associated with onset in childhood[10].

However a non-familial form of vibration urticaria is also recognised, also associated with increased plasma histamine levels[11]. Following a meta-analysis of 22 studies Kulthanan recommended that such urticaria be classified into hereditary and acquired[12], noting that although vibration-induced itching was frequent in both groups, those with the hereditary variant more frequently experienced wheals and systemic symptoms, while those with the acquired form had angioedema, burning, pain, or tingling.

In this case the authors reported that the urticarial response was eliminated by 'a state of tolerance to vibration … induced by graded increased exposure to vibratory stimulus'.

In 2021 a classification for vibratory urticaria was proposed (fig 1):

Types	Subtypes	Pathogenesis	Clinical course	Clinical features
Hereditary vibratory urticaria / angioedema	Hereditary vibratory angioedema (Patterson type)	Hereditary (autosomal dominant): unknown mutation(s)	Chronic	Angioedema (hours)
	Hereditary vibratory urticaria (Boyden type)	Hereditary (autosomal dominant): ADGRE2 mutations (Lebanese families	Chronic	Hives (<1 h)
Acquired vibratory urticaria / angioedema Severe	Acquired vibratory angioedema	Idiopathic	Chronic	Angioedema (hours)
	Secondary acquired vibratory urticaria	Self-limited and triggered by an identifiable cause (infection, Hymenoptera sting)	Acute / subacute (symptoms triggered by vibratory stimuli until the primary condition is resolved	Hives (<1 h) / anaphylaxis

Figure 1 – after Pastor Nieto M, Gatica-Ortega M, Vergara-de-la-Campa L, Giménex-Arnau L [13]

Occupational causes

There are few reports of occupational vibratory urticaria/ angioedema, although it has been reported among a range of occupations, including using drills, jackhammers[14], grinders, lawn mowers as well as driving, cycling, jogging, fast walking[15] or riding motorcycles. Some case reports appear to describe urticarial responses to several stimuli in individuals so affected. The author has been unable to find reports which relate the development of such urticaria to particular patterns, frequencies or levels of vibration exposure.

It is recognised to occur among musicians, with reports in the lips of a trumpet player[16] and the lower lip of a saxophonist[17]. The case report of the trumpeter noted that, unlike woodwind players, those playing brass instruments rely on their vibrating lips to make a sound.

Carpal tunnel syndrome has been reported as a complication of vibratory angioedema affecting the hands after using vibratory tools[18]. In that case laboratory exposure to vibration produced both an increased plasma histamine level and reduced median nerve conduction velocity.

A case of vibration induced angioedema with systemic symptoms of tachcardia and hypotension has been reported[19] and one of vibration as the primary trigger for anaphylaxis after use of a massage bed[20].

Occupational health management

As with other workplace allergies, correct diagnosis is the starting point. This will include taking a careful family history, although recognising that both familial and non-familial forms will exist. Where vibration angioedema is suspected consideration should be given to referral for formal allergy testing with a vibratory stimulus, while also reducing the exposure of the employee to the likely work process. It may be that the latter action provides a clear resolution of symptoms in which case further investigation may not be required. It is also important to exclude other forms of contact urticaria and physical urticaria, such as cold, which may be relevant to those using pneumatic tools which also produce vibration.

International guidelines recommend a stepwise approach to treatment, including avoidance of trigger factors and initial treatment with second generation H1 antihistamines[10].

Whether or not an attempt is made at graded re-exposure to vibration after initial control of the symptoms will be a matter of individual clinical judgement and discussion with the employee.

While unreported as a feature of occupational vibration exposure, treatment of anaphylaxis should follow Resuscitation Council Guidelines[21]

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APPENDIX M
CAPILLAROSCOPY

Background

Although a clear understanding of the pathophysiology of HAVS remains uncertain[1] various clinical tests have been developed by researchers. With regard to the vascular component these have centred around measuring either vasospasm or vasodilatation: cold water provocation testing and finger systolic blood pressure, FSBP. Whilst the latter has been used in Tier 5 assessments or as an objective measure in medico-legal cases the advent of mobile phone photography has largely superseded the requirement for these tests.[2]

A history of appropriate symptoms, sufficiency of exposure and the exclusion of other causes remains the mainstay of diagnostics in HAVS. Despite this cases will arise where the differentiation between primary Raynaud's phenomenon, PRP and secondary Raynaud's phenomenon, SRP are not always readily achieved. A relatively common example being the onset of Raynaud's phenomenon in a worker already using hand-held vibrating tools. Whilst pointers in the history and examination may suffice the emergence of a simple clinical test to support the differentiation of PRP from SRP would aid in diagnostics. In addition an onset of Raynaud's phenomenon in older age groups will always raise the issue of potential connective tissue disorder.[3]

These brief appendix introduces a clinical procedure, nailfold capillaroscopy with the potential for future practical application in tier 4 health surveillance.

Capillaries form 'loops' in the micro-vasculature that runs under the surface of the skin in the nailfold of the fingers (fig.1):

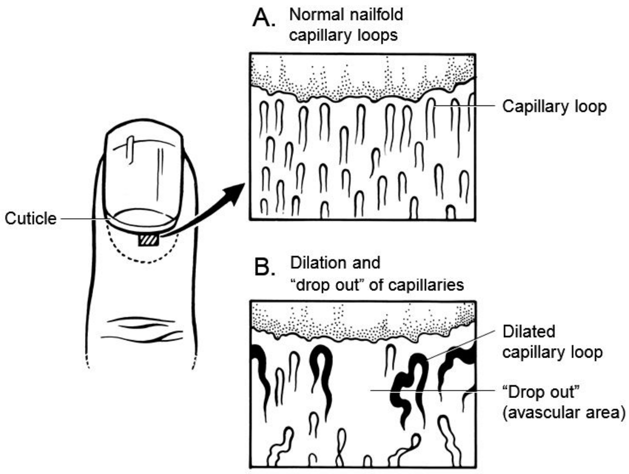

Figure 1: Nailfold Capillaroscopy

https://www.rheumaknowledgy.com/nailfold-capillaroscopy/

The loops of vessels are normally viewed using a capillaroscope or microscope under magnification. They have a hairpin like shape or inverted 'U' spaced evenly and symmetrically as shown in figure 1 A. The shape and dimensions of the loops have been studied to standardise the technique in PRP and determine if it was possible to differentiate PRP from SRP.[4,5] PRP shows a normal pattern of loops and spacings whereas SRP shows a 'scleroderma pattern' of abnormalities with less and dilated capillaries, haemorrhages and avascular areas. Whilst these tests are usually undertaken in the rheumatology clinic with suitable training an ophthalmoscope can be used. In a small prospective study comparing ophthalmoscopy with a stereomicroscopy Anders found the former as comparable for use in the clinic setting.[6]

Occasionally some changes can even be seen with the naked eye (Figure 2).[4]

Figure 2: From Smith V, Herrick A L et al 2020[4]

Capillaroscopy in HAVS

If the capillaroscope can define normal and abnormal patterns it begs the question of whether there is a putative role in HAVS surveillance. Unfortunately the literature is sparse on this. However a study by Chen et al of 113 male gold miners, under blinded conditions, using the technique of nailfold video-capillaroscopy showed promising potential.[7] They compared nailfold morphology in workers with vascular HAVS (35) alongside groups of vibration exposed and non-vibration exposed (39 VEC and 39 NVEC). There was a significantly higher percentage of haemorrhages and other morphological changers in the HAVS group (65.7%) compared with the other two groups (VEC 7.7% and NVEC 7.5%).

Whilst further studies are required, the advent of dermatoscopes and smartphones with cameras for use in tier 4 assessments clinical settings has the potential to become a useful addition to health surveillance. Occupational health practitioners may consider attending rheumatiology clinics to learn the basic morphological changes that can then be applied when using an ophthalmoscope.

Ophthalmoscopy Technique

Set at red 20 diopters and adjust as required/ Put small drop of oil on the cuticle nailfold of the fourth and fifth digits where the best translucency is seen. Look at a distance of about 1.5 cm to view either a normal pattern (PRP) or for any dilated capillaries, haemorrhages or reduced capillaries (SRP).

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APPENDIX N
PROGNOSIS OF HAND-ARM VIBRATION SYNDROME

Occupational health practitioners may be asked to provide advise to employers on 'the likelihood of disease progression with continued exposure' (HSE guidance L140 para 198, 2019). In this context this brief appendix has been added to summarise the limitations of the epidemiology on prognosis in HAVS. The intention is to provide some general background information on prognosis and reversibility to assist with decisions on continuing exposure and fitness for work (cf Section 15). This is particularly relevant given the limitations of readily tolerated and effective medical treatments.

Hand-arm vibration syndrome is essentially a more or less condition determined largely by subjective assessment of symptoms.[1] Whilst mobile phone photography, quantitative sensory testing and nerve conduction studies can assist in differential diagnosis and severity staging the progress of an individual case is largely determined by subjectivity.[2,3] Although some studies have included objectivity these have been hampered by the inherent limitations in the available tests particularly the vascular component.[4,5] Attempts to study the latter are reduced to an individual's perception of progression or reversal in terms of symptom extent, frequency and functional impacts.

A dearth of prospective studies is probably reflective of intangibles such as preventative avoidance behaviours lessening cold exposure that trigger attacks of vasospasm or the presence or otherwise of a company policy on HAVS influencing the survivor effect. The use of but limited effectiveness of pharmaceutical treatments adds another co-variable to the interpretation of prospective epidemiological studies. A review of dose-response relationships found the evidence on reversibility was limited.[6] Another factor is that follow up time in studies after stopping exposure may not be long enough: a SIG member had the opportunity to follow-up cases for over ten years reporting complete reversal symptomatically with objective support from improvements in tier 5 test results.

The Health and Safety Executive, HSE Workplace Health Expert Committee (WHEC) carried out a review of prognosis in HAVS concluding that the research is sparse and somewhat contradictory.[7]

One key determinant of reversibility is ongoing exposure. The review included two summaries of recent 22 year studies by Aarhus et al.[8,9] These concluded that with ongoing vibration exposure, whilst there is minimal change in numbness, there is no significant reversibility in sensorineural component and minimal progression in vascular symptoms. The finding of a plateauing effect in vascular HAVS is supported by expert opinion.[10] It has previously been reported that reversibility is weaker in severer vasospastic disease and that smoking may hinder recovery.[11]

With these limitations in mind the HAVS SIG offers some general conclusions on reversibility and prognosis which may assist decisions regarding individual advise regarding ongoing exposure. Ultimately management decisions are based on both the rate and stability of clinical progression, the prevention of irreversible damage and the availability of alternatives to continued exposure.

Reversibility

A pragmatic approach is to consider a reduction in the extent of finger blanching or number of fingers affected. Frequency of attacks is more likely to reflect avoidance behaviour and preventative actions. Reversibility is less likely for more severe vascular stages. For sensory symptoms although improvement is unlikely a lessening in numbness and or tingling and improvement in dexterity may be used. Where available this could be supported by QST.

Prognosis

The onset, progression and functional impacts are largely determined by a combination of individual and workplace factors. Plateauing may be seen in vascular HAVS at 1V and 2V despite ongoing exposure. Although ongoing exposure to hand transmitted vibration is the prime determining factor cold exposure in the workplace may be a synergistic factor[12] amenable to control along with advice to stop smoking.

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APPENDIX O
HAND-ARM VIBRATION SYNDROME AND THE THUMB

The accepted view amongst clinicians is that if the thumb is affected in hand-arm vibration syndrome (HAVS), it is a late presenting symptom or an indication of severity in the vascular component. This acceptance of severity has been incorporated into the scoring scales assigning higher digital scores to proximal and distal phalanges of thumbs compared to fingers (Griffin 1982,1990; Rigby, Cornish 1984). One putative explanation is that most tool handle grips adopt a power type grip separating the thumb from the vibrating surface by the fingers (Fig. 1). This hypothesis is countered by the frequent presentation of vasospasm affecting the thumbs, fore and middle fingers in pedestal grinders who adopt a tripod configuration of these digits to grip the workpiece (Fig. 2).

Figure 1: Power grip

Figure 2: Tripod grip

However a cross-sectional study (Chikura et al 2008) of symptoms and thermography looking at distal-dorsal difference (DDD at 23°C) of 44 sufferers of Raynaud's phenomenon (RP) found sparing of the thumb in both primary(PRP) and secondary forms (SRP). The authors speculated that this was a result of either a well developed dorsal arterial blood supply to the thumb providing an independent vascular axis, or simply that the thumb was physically shorter and therefore impacting clinical presentation. The latter view supported by the little finger being the second least symptomatic digit. There have been numerous studies of the arterial supply to the thumb supporting its rich uniqueness (Brunelli & Gilbert 2001).

Using the same technique of DDD Chikura (Chikura et al 2010) carried out a prospective study of 170 and found the thumbs were significantly warmer compared with other digits ($p < 0.001$) in both PRP and SRP. In addition the digits were warmer in PRP compared to SRP with the exception of the thumbs where the difference was more pronounced in SRP. The conclusion being that the involvement of the thumb should alert the clinician to the possibility of SRP, a connective tissue disorder (CTD), putatively a result of differences in pathophysiology between PRP and SRP. Primary Raynaud's being one of a central autonomic effect and secondary being due to local effects (Raynaud 1862, Lewis 1929).

Where does that leave involvement of the thumb in vibration exposed? If the thumb is affected it is a possible indication of SRP which could be HAVS or other potential causes which should be excluded. Differentiators such as those presenting for the first time over the age of 30 yrs including any with physical signs e.g. swollen fingers suggesting CTD should be investigated (Cooke et al 2023). This is good practice and in keeping with principles of the HAVS three part diagnostic test (Montracon -v- Whalley 2005):

a. a history of exposure to vibration sufficient to cause a risk of development of the condition (HAVS),

b. a clinical history and description of symptoms which is consistent with one or more components of HAVS, and

c. the absence of any constitutional explanation for the symptoms.

However in practice, with background probability of CTD being low, excluding the above differentiators, investigation in large cohorts undergoing health surveillance is hard to justify. In all likelihood most cases who present with thumb symptoms, particularly if other fingers were affected first, with asymmetry of exposure or grip is supportive of HAVS but referral to a rheumatologist in older workers with late onset may be prudent.

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APPENDIX P
CUBITAL TUNNEL SYNDROME AND WORK WITH HAND-HELD VIBRATING TOOLS

Key messages

1. The SOM HAVS SIG has previously stressed the importance of distinguishing between hand-arm vibration syndrome (HAVS) and carpal tunnel syndrome (CTS). Another common upper limb nerve entrapment is Cubital Tunnel Syndrome (CuTS) requiring similar consideration.*

2. Early identification is preferable to prevent demyelination and axon damage leading to poorer treatment outcomes

3. Whereas exposure to hand-held vibrating tools is a 'certain' cause of hand-arm vibration syndrome (HAVS) and a 'probable' cause of CTS, this brief review of recent peer reviewed literature suggests that the role of work with hand-held vibrating tools in the development of CuTS is considered 'uncertain/unlikely'.

4. Any consideration regarding workplace restrictions should be confined to symptom severity and function that may impact fitness for work.

5. The overall message for health surveillance of vibration exposed is to increase the index of suspicion of CuTS, and earlier referral.

** This publication should be read in conjunction with associated HAVS SIG publications on entrapment neuropathies: 'Carpal tunnel syndrome and work with hand-held vibrating tools' and 'Nerve Conduction Studies (NCS) in workers exposed to Hand-Transmitted Vibration (HTV)'.*

Background

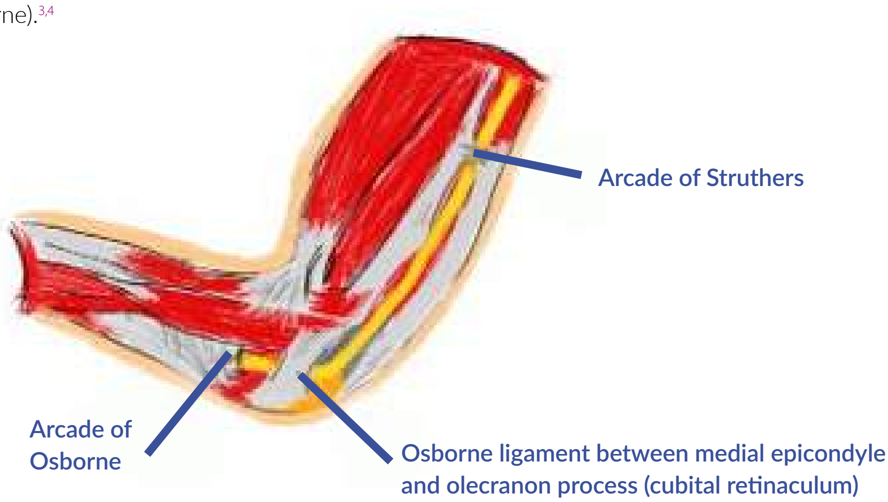
After carpal tunnel syndrome (CTS) cubital tunnel syndrome (CuTS) is often reported to be the second commonest peripheral nerve entrapment (sometimes referred to as ulnar nerve entrapment at the elbow, UNE). Despite this claim the supporting epidemiology is limited and dependent on case definition. A cross sectional study of over 1000 found CuTS to be between 1.8% and 5.9% of the general population.[1] A large US population cohort study put the overall adjusted incidence at 30.0 per 100,000 person-years increasing significantly with age and a slightly higher incidence in males.[2]

Anatomy

The ulnar nerve can be compressed at a number of locations in the upper limb. With spinal roots arising from C8 and T1 the nerve passes through Struther's arcade (see footnote 1) between heads of triceps medially to enter cubital tunnel at retro-epicondylar groove under Osborne's ligament before passing beneath the aponeurosis of flexor carpi ulnaris (FCU) origins or arcade of Osborne (see Fig 1 below). It then enters the hand through the Guyon tunnel.

The location of entrapments are multiple along this route (see footnote 2) but it is thought that most significant compression occurs between the heads of FCU (Arcade of Osborne).[3,4]

Fig 1. Cross section of medial aspect of elbow showing passage of ulnar nerve (yellow)



Footnote 1: There are contrary reports in anatomical studies on the existence or otherwise of this arcade although its role may be more important in recurrence after transposition:

https://pubmed.ncbi.nlm.nih.gov/12748890/

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5497011/

Footnote 2: A comparison study found site of compression varied between manual and sedentary work:

https://pubmed.ncbi.nlm.nih.gov/26093933/

Risk factors for developing CuTS are similar to CTS and include obesity, diabetes and smoking. The association with age and body mass index has however been challenged.[5]

Presentation

The usual presentation is tingling and numbness in the little and ring fingers and along the ulnar aspect of the hand. Pain on the medial aspect of elbow and forearm is also reported.[6] Although medial elbow pain is not necessarily a clear diagnostic symptom of UNE,[7] with potentially a multifactorial causation requiring a broader differential diagnosis e.g.Golfer's elbow.[8]

Atypical history is of frequent nocturnal symptom presentation, commoner in 'foetal' sleepers (flexed elbows) or in those reporting exacerbation when using a mobile phone.[3] There maybe pain or discomfort around the elbow and forearm. More severe and longer term cases may present as hand weakness and clumsiness with both weakened power gripping and oppositional problems such as holding a pen. The most severe cases may present with a 'claw' hand.

Diagnosis

There is a lack of international consensus regarding the required diagnostic criteria for CuTS.[6] Graf et al, noting the controversy regarding diagnosis and treatment, indicated that over 500 articles on CuTS have been published in the past decade progressing the development of diagnostic and treatment options but still lacking a standardised algorithm. In addition an earlier diagnosis and management is preferable to late presentation where surgical outcomes are less predictable.[3]

Weakness and wasting of the first dorsal interossei (FDI) is an indication of severity. The ulnar nerve can be palpated in the cubital tunnel whilst passively flexing and extending the elbow: a subluxing of the nerve, although present in the asymptomatic, has been shown to be a risk factor for CuTS.[9]

Provocative sensory tests include Tinel's at the elbow and fixed flexion tests. The former by either tapping the ulnar nerve on the medial side of the elbow and the latter by holding elbows in fixed flexion for 3 minutes. Positive results are indicated by reproduction of symptoms along the ulnar nerve. Novak reported a 70% sensitivity in Tinel's sign and 30% for elbow flexion test but increasing to 91% when combined with pressure on the ulnar nerve.[10]

Motor function tests are designed to detect weakness in FCU and dorsal interosseii. These include flexing the wrist against resistance in ulnar direction and testing opposition of thumb with little finger against resistance. Froment's sign is elicited by asking the candidate to grip piece of paper between thumb and index finger which elicits flexion at the interphalangeal joint of the thumb as the paper is removed against resistance (adductor pollicis muscle failing to adduct compensates by thumb flexion).

Another late sign, caused by weakness of the 3rd palmar interosseous muscle and fifth digit lumbricals is demonstrated when the candidate holds all fingers in adduction the small finger begins to abduct relative to other fingers (Wartenberg's sign).

Collins et al[11] undertook a Delphi exercise of 12 surgeons and found agreement as follows :

1. Paresthesias in ulnar nerve distribution
2. Symptoms precipitated by increased elbow flexion/positive elbow flexion tests
3. Positive Tinel sign at the medial elbow
4. Atrophy/weakness/ late findings (eg, claw hand of the ring/small finger and Wartenberg or Froment sign) of ulnar nerve-innervated muscles of the hand
5. Loss of two-point discrimination in ulnar nerve distribution
6. Similar symptoms on the involved side after successful treatment on the contralateral side.

MacDermid and Grewal - conscious of the uncertainty surrounding the best approach to treatment identified in a Cochrane review[12] (updated in 2016) - developed a patient reported outcome measure for ulnar nerve entrapment, PRUNE (Appendix 1).[13]

In terms of assessing pain, disability and quality of life PRUNE has been shown to be the preferred condition specific PROM.[14] Although promoted as research tools to monitor treatment outcomes it does not have the diagnostic efficacy of say the equivalent in CTS e.g. Boston Carpal Tunnel Questionnaire, but could play a role in health surveillance.

As well as the lack of agreed diagnostic criteria the other drawback relevant to management and treatment is the lack a classification based on the severity of symptoms which should be a matter of future research.[6] Mirza et al looked at classifying CuTS during endoscopic surgery using the presence of subluxation and devised a treatment based staging on ulnar nerve instability (UNI).[15]

Most differential diagnoses are rare and include C8-T1 radiculopathies with similar symptoms to UNE although dermatomal loss of sensation on the medial aspect of the forearm would suggest a nerve root origin. Another is compression of the ulnar nerve in the Guyon tunnel (Guyon or Ulnar tunnel syndrome, UTS) either from ganglions, cysts or fractures to the hook of hamate or in association with vascular symptoms of hypothenar hammer syndrome (HHS). ‘Clawing’ is more likely to suggest UTS than CuTS.[6] Histories that suggest alternative diagnoses should have nerve conduction studies performed to determine if compression is proximal to the wrist or proximal to the elbow.

Cubital Tunnel Syndrome in Vibration Exposed

Adopting nomenclature developed by WHEC[16] exposure to hand-held vibrating tools is a ‘certain’ cause of hand-arm vibration syndrome (HAVS) and a ‘probable’ cause of CTS.[17] The following summary of a limited literature review suggests the role of work with vibrating tools in the development of CuTS remains ‘uncertain/unlikely’. Whilst the site of damage in vibration exposed workers needs to be determined studies of CuTS in vibration exposed are limited by the uncertainty of background prevalence and suitable comparison groups. Biological plausibility and confounding ergonomic risk factors contribute to these doubts over attribution.

A neurophysiological study by Stromberg et al on 73 symptomatic vibration exposed workers found evidence of median nerve entrapment but not of the ulnar nerve.[18]

Two studies by Kakosy provides some apparently compelling figures supporting causal attribution but these have not been reflected in other studies. The earlier one investigated vibration exposed workers (n=167) by nerve conduction studies (NCS) and electromyography and found a high prevalence of upper limb compressive neuropathies (42.5 per cent CuTS).[19] However a later retrospective study of 154 vibration exposed foundry workers found 41 cases of ‘distal’ type neuropathy and fewer cases (21) of compressive neuropathy.[20]

Lander et al undertook an NCS study in vibration exposed and found the predominant neurological prevalence were neuropathies of the ulnar and median nerve proximal to the hand (right CTS 33%, left CTS 22%; right Ulnar neuropathy 11%, left Ulnar neuropathy hand 9%.[21]

Dasgupta et al in a questionnaire and NCS study of jack hammer users found 23 cases of ulnar nerve neuropathy (n= 66 jack hammer).[22] Sanden et al in a longitudinal study between 1987 and 2008 of 155 male office staff and manual workers using NCS found no differences between the groups for either median or ulnar nerves.[23]

In a recent study NCS by Ahmed et al (n=431) whilst finding an overall higher prevalence of compressive neuropathies in patients examined for HAVS showed a result of 7% ulnar neuropathy.[24] A figure that compares with the upper limits of population prevalence.[1]

Zimmerman et al using qualitative descriptors in a large population cohort found that ‘much’ exposure to hand-held vibrating tools was independently associated with UNE in men (HR 2.42 (95% CI 1.15 to 5.07) and ‘some’ exposure (HR 2.10 (95% CI 1.12 to 3.95).

However in their conclusion they stressed the importance of considering comorbidity of CTS and UNE and other risks e.g. age, smoking, alcohol, hypertension and diabetes.25

These and other occupational risks including vibration exposure have been reviewed by Miettinen et al concluding that sufficient evidence for a causal link between occupational exposure and UNE is lacking. However they did report that workers exposed to hand arm vibration had an HR = 1.94, 95% (CI 1.00–3.77) and were at increased risk of hospitalisation for UNE.[26]

As stated above it is important in health surveillance to distinguish between symptoms arising from sensory HAVS and other upper limb entrapments. Where there is doubt about the site of injury from history and clinical examination the combination of NCS and sensorineural testing may be necessary.[27,28]

Management and Treatment

A clinical algorithm combining diagnosis, NCS and treatment pathways has been proposed reserving NCS for FDI weakness or wasting and failed conservative treatment.[3] The results of the latter determining treatment options;

- **Mild:** conservative orthosis/splint (3 month trial)
- **Moderate** (decreased conduction velocity): surgical decompression plus transposition if nerve unstable at operation.
- **Severe** (decreased CMAP): surgical release as above plus or minus nerve transfer.

A return to work after surgical decompression usually 6 weeks but greater if nerve transposition is undertaken.[29]

The message for health surveillance of vibration exposed is to increase the index of suspicion and for earlier referral to improve long term outcome. The contribution of vibration to attribution in most cases is unlikely from the epidemiological evidence although tool specific ergonomic factors should be considered.[30] Any consideration regarding workplace restrictions should be informed by symptom severity and function that may impact fitness for work. The PRUNE questionnaire maybe helpful in this respect.

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APPENDIX P.1
PRUNE (MACDERMID AND GREWAL 2013)[13]

PATIENT RATED ULNAR NERVE EVALUATION

NAME:____ DATE: __________________________

*The questions below will help us to understand the amount of pain or difficulty you experience because of your hand / arm. Please describe your **average** experience **over the past week**.*

Rate your PAIN: 0= no pain, 10 = worst possible											
When it is at its worst	0	1	2	3	4	5	6	7	8	9	10
At rest	0	1	2	3	4	5	6	7	8	9	10
In the morning	0	1	2	3	4	5	6	7	8	9	10
After work/activity	0	1	2	3	4	5	6	7	8	9	10
At night (when sleeping)	0	1	2	3	4	5	6	7	8	9	10
How often do you have pain (0 = never, 10 = always)	0	1	2	3	4	5	6	7	8	9	10
Rate your OTHER SYMPTOMS: 0 = none, 10 = worst possible											
Numbness in my little finger	0	1	2	3	4	5	6	7	8	9	10
Pins and needles in my little finger	0	1	2	3	4	5	6	7	8	9	10
Unable to control the position / movement of my little finger	0	1	2	3	4	5	6	7	8	9	10
Weakness in my hand (pinch / grip)	0	1	2	3	4	5	6	7	8	9	10

Rate your DIFFICULTY performing the following: 0 = no difficulty, 10 = completely unable											
Eat (use knife, fork, chopsticks)	0	1	2	3	4	5	6	7	8	9	10
Lift a heavy object	0	1	2	3	4	5	6	7	8	9	10
Hold an object (i.e. tool, book, electronic device) for 1 hour	0	1	2	3	4	5	6	7	8	9	10
Repeated reaching	0	1	2	3	4	5	6	7	8	9	10
Tasks with repetitive finger use - typing, playing musical instrument, handling small objects	0	1	2	3	4	5	6	7	8	9	10
Turn a key / doorknob / handle	0	1	2	3	4	5	6	7	8	9	10
Rate your DIFFICULTY performing usual activities that you did before your hand/arm problem started: 0 = no difficulty with ANY of my usual activities, 10 = COMPLETELY UNABLE to perform my usual activities											
Personal care (washing, dressing etc.)	0	1	2	3	4	5	6	7	8	9	10
Household (cleaning, maintenance)	0	1	2	3	4	5	6	7	8	9	10
Work (job or everyday work)	0	1	2	3	4	5	6	7	8	9	10
Recreational activities	0	1	2	3	4	5	6	7	8	9	10

Sourced from PMC: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3660194/figure/F1/

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