Hand-Arm Vibration at Work

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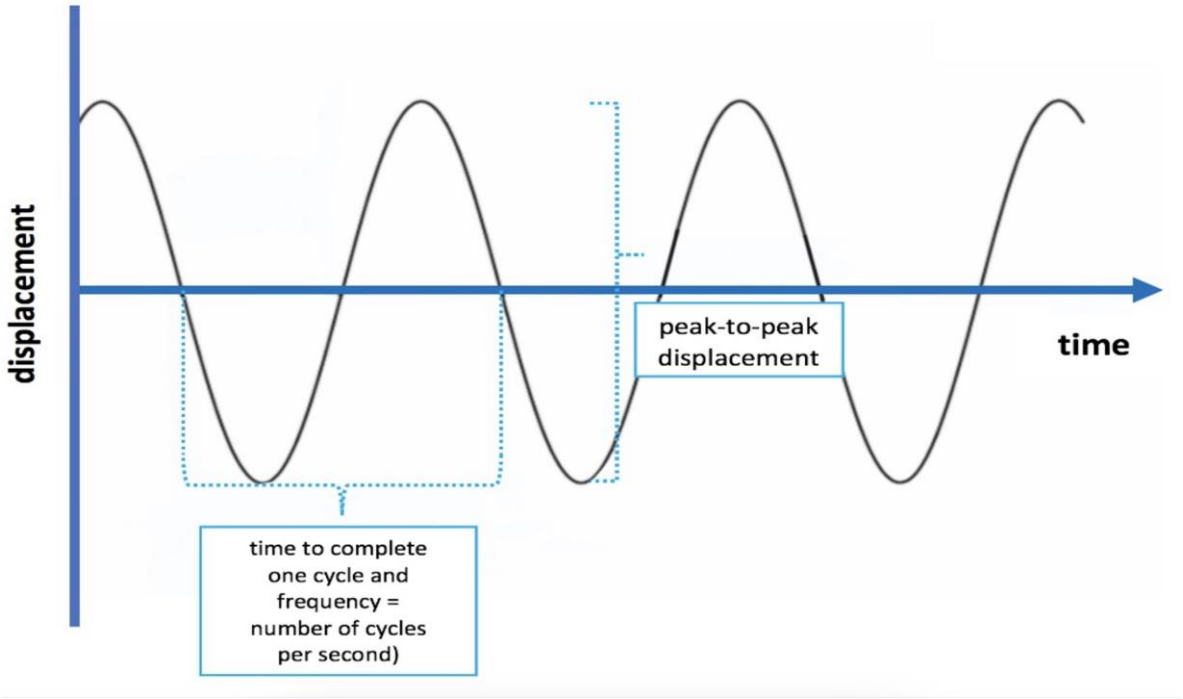
Hand-Arm Vibration at work

- Vibration physics & measurement
- Vibration related disorders
- Vibrating tools and equipment
- Hand-arm vibration syndrome, HAVS
- Carpal tunnel syndrome, CTS
- Dupuytren's contracture, DC
- Policy and Regulations
- Health surveillance and investigations
- Management of cases- HSE Guidance

Vibration

- Hand-arm vibration, HAV (Hand transmitted vibration, HTV)

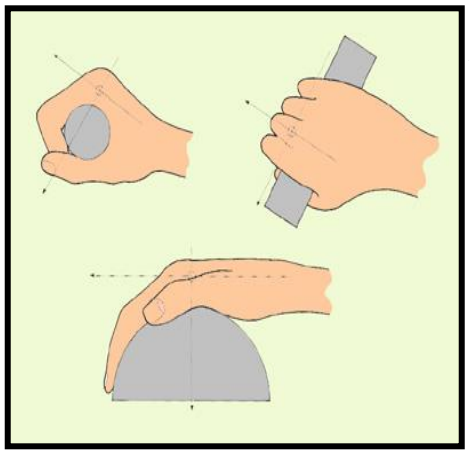


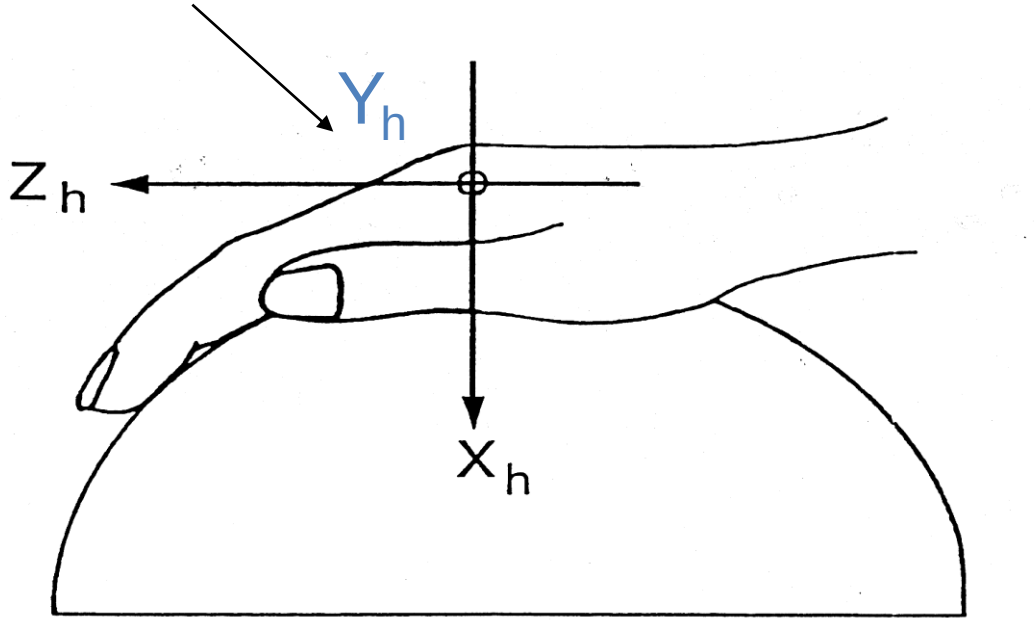
- Vibration parameters: displacement (m), velocity (ms-1), acceleration (ms-2)
- Frequency, f: 1-1000 Hz?
- Weighting of lower frequency <16 Hz (percussive tools) vs higher frequency 16-250 Hz
- Magnitude of vibration - root mean square (rms) acceleration value, ahw

Vibration magnitude

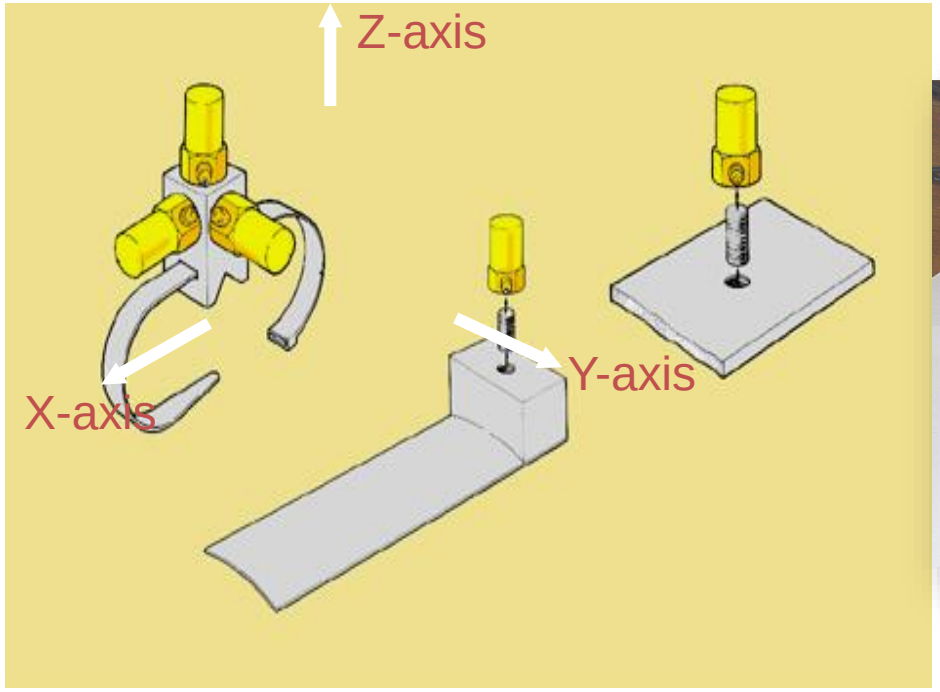
Vibration magnitude as ‘Average’ (r m s)acceleration over an 8 hour day $A(8) = a_{hw} \checkmark (t/T)$

Vector sum and dominant axis





Accelerometer mounting



Fastened to tool or held by operator

Control of Vibration at work Regulations 2005 (CVAWR)

- + Guidance on Regulations (L140)
- Measurement standardised: ISO 5349-1/2
- Based on sum (rms) of values on 3 axes
- Exposure Action Value* EAV = 2.5 ms^{-2}
- Exposure Limit Value* ELV = 5 ms^{-2}

*EAV: is a daily amount of vibration above which employers are required to take certain actions to reduce exposure

*ELV: Maximum exposure to vibration in any single day

HAVS

Alice Hamilton
1918

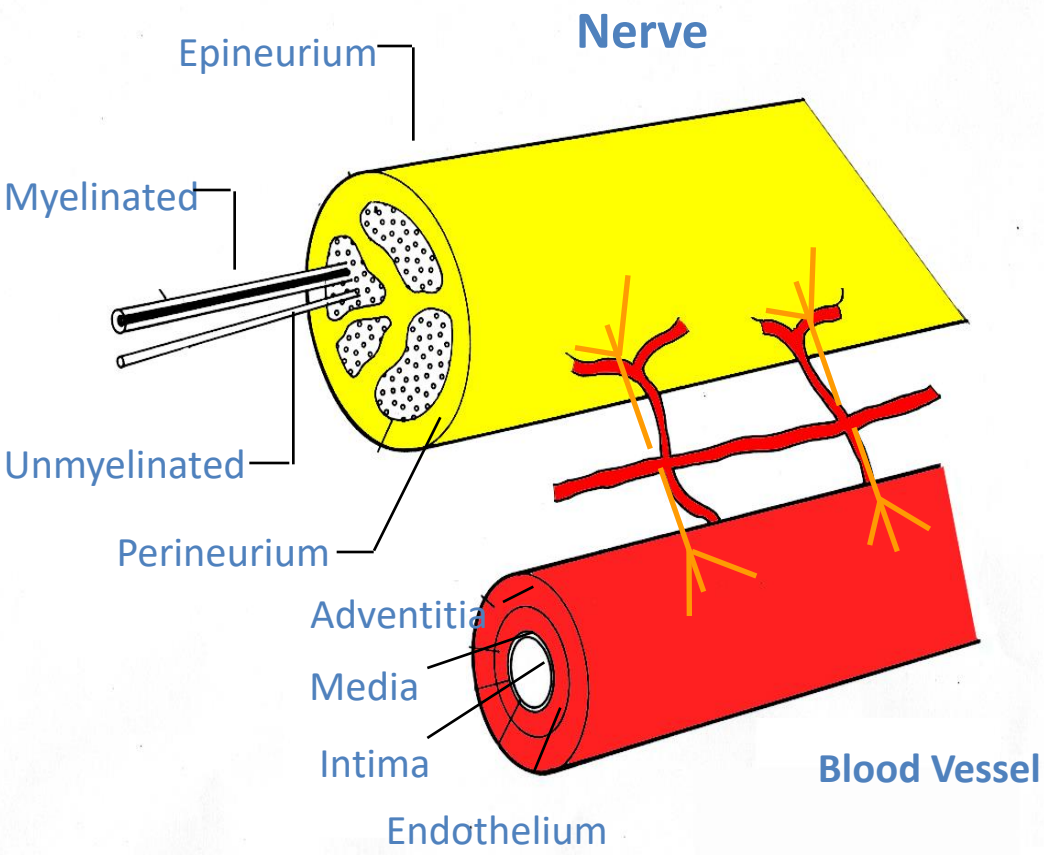
“The men call the condition ‘dead fingers’ and it is a good name, for the fingers do look like those of a corpse, a yellowish-greyish white and shrunken. There is a clear line of demarcation between the dead part and the normal part.”

HAVS – prevalence data

- One of the commonest Occupational Diseases
- 4 million exposed (c 7% of pop)
- c 30 million cases worldwide
- c 220,000 cases of VWF and 300,000 sensorineural HAVS in GB (HSE)
- Medical Assessment Process

  >150,000 ex-miners UK, 1999

Microanatomy



Jobs associated with hazardous vibration

Metal workers	Motor cyclist
Grinders	Motor mechanics
Cutters	Sheet metal workers
Dentists	Orthopaedic surgeons
Miners	Caulkers
Ship-builders	Boilermakers
Forestry workers	Welders / platers
Road workers	Shoe manufacturing
Construction workers	Quarry workers

Tools and processes associated with hazardous vibration

- Percussive metal working tools
- Grinders & rotary tools
- Percussive hammers and drills used in mining
- Forest & garden machinery
- Miscellaneous tools & processes

Vibration related conditions

- Hand Arm Vibration Syndrome
  - Sensory (paraesthesia, dysaesthesia, reduced sensory perception and dexterity)
  - Vascular (cold induced vasospasm: ‘VWF’)
- Carpal Tunnel Syndrome
- Dupuytren’s Contracture
- Hypothenar Hammer Syndrome
- Musculoskeletal component:
  - Muscular weakness?
  - Osteoarticular (osteoarthritis, bone cysts)?

HAVS Diagnosis

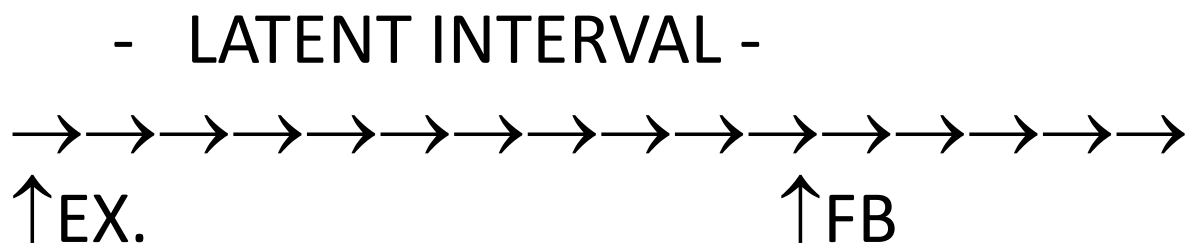
How is the diagnosis of HAVS made?

(Montracon-v-Whalley, 2005)

- history of exposure to vibration sufficient to cause
- appropriate symptoms
- exclusion of other causes

Latent Interval

- Time between first exposure an onset of finger blanching, FB



- 6months - 20+years
- symptoms developing more than two years after the cessation of exposure should not be attributed to vibration

Sensorineural component

- Numbness and tingling should be treated synonymously.
- Numbness is poorly described ;
  “Fingers feel fat”
  “Like in a boxing glove”
- Persistent numbness and/or tingling in warmth is an indication of severity
- Dexterity loss in warmth is required for severe staging

Vascular Component

- Raynaud's Phenomenon (RP):

Descriptive term indicating episodes of digital ischaemia provoked by cold (vasospasm). The affected fingers turn white with loss of sensation.

- Can be triphasic or biphasic:

Whiteness followed by blueness (cyanosis) followed redness (reactive hyperaemia).

- Need to differentiate between primary Raynaud's Phenomenon, PRP and secondary Raynaud's Phenomenon, SRP (e.g. CTD or HAVS)

PRP v HAVS

Onset and progression

Asymmetry

Periphery – caution re feet (House et al 2011)

Family history

Thumbs (tripod grip)

Sharply demarcated, circumferential, nails

Right little finger

Trophic changes – think some other diagnosis?

Hand Arm Vibration Syndrome (SWS 1987) Vascular component (V) each hand

Stage	Grade	VWF Attacks
0	-	Nil
1	Mild	Tips only, winter
2	Moderate	Distal & middle phalanges (occasional proximal)
3	Severe	Whole Finger most digits frequent attacks
4 (?)	Very severe	Trophic skin changes

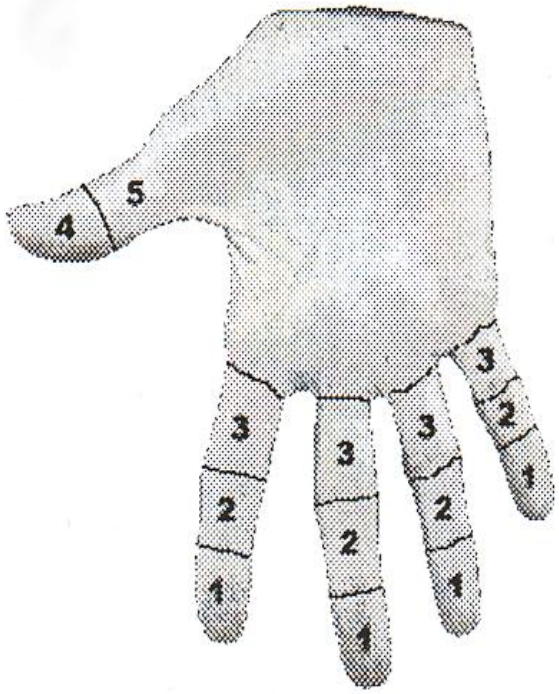
* Grade indicated by stage and number of affected fingers on each hand, e.g. 2R(2) : 1L(1)

SWS 1987 Sensorineural component (SN)

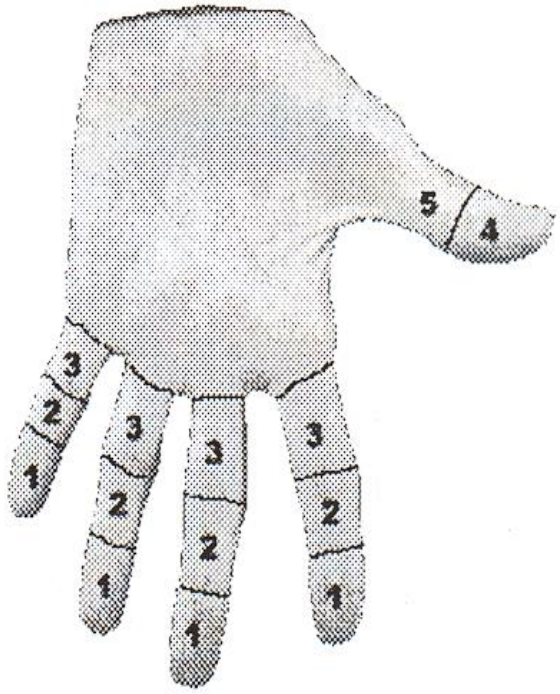
Stage	Symptoms
0_{SN}	Nil
1_{SN}	Intermittent numbness with or without tingling
2_{SN}	Intermittent or persistent numbness reduced sensory perception
3_{SN}	Intermittent or persistent numbness reduced tactile discrimination and / or manipulative dexterity

(d) Which fingers are affected?

Right Hand



Left Hand



Blanching Score right

Blanching Score left

Sensorineural SWS modification

0_{SN}	Nil
1_{SN}	Intermittent numbness and/or tingling
2_{SN} early	Intermittent numbness and/or tingling
	+ reduced sensory perception (W Monofilament)
2_{SN} late	persistent numbness and/or tingling
	+ reduced sensory perception (W Monofilament)
3_{SN}	Constant numbness and/or tingling + reduced sensory perception (W Monofilament) + manipulative dexterity reduced in warmth (PPT+ve) ± Jamar

Persistent = > 2 hours, Constant = all the time

Vascular SWS modification

Stage	Vasospastic attacks
0	None
1V	Fingertips only (1-4)
2 V early	Occasional distal and, middle, (rarely proximal), phalanges (usually blanching score 5-9)
2 V late	Frequent distal and, middle (rarely proximal), phalanges (usually blanching score 10-16)
3	Frequent attacks all fingers most, digits all year (usually blanching score 18)

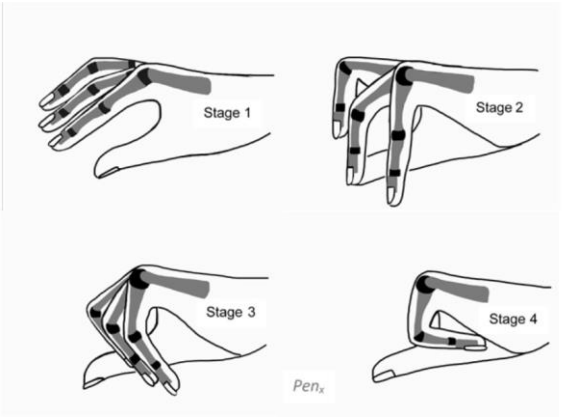
Frequent > 3 per week (Extent overrides Frequency)

Carpal Tunnel Syndrome and HTV SOM SIG 2021

- Doubling of relative risk from work with handheld vibrating tools
- A lower the threshold of suspicion of CTS in HTV exposed
- Advice on diagnoses by anamnesis
- Co-morbidity of CTS and HAVS possible: exclude HAVS and treat CTS first and only grade after treatment
- Use of splints while awaiting investigation
- Surrogate diagnosis of entrapment neuropathy – carpal tunnel steroid injection
- Nerve conduction studies NCS may assist in diagnosis but have significant false negative rates

Dupuytren's Contracture SOM SIG 2022

- Prescribed Disease PD A15 (2018)
- Staging fixed flexion contracture – Tubiana
- A significant number of DC cases affect the metacarpophalangeal joints only
- A minority of nodules can progress to contracture – document finding
- Fitness for work functionally based – yet Quadriga



Policy on HAVS (CVAWR 2005, L 140)

- Identification (Index cases)
- Risk assessment (supplier information, measurement?)
- Health surveillance (Tiers)
- Case management
- Information and training
- Exposure control

Why do health surveillance?

- Detection of adverse health effects at an early stage
- Identifying and protecting individuals at increased risk
- Feedback on risk assessment
- Effectiveness of control measures

Control of Vibration at work Regulations 2005.

Guidance on Regulations (L140) :Exposure Action Value= 2.5 ms^{-2}

Prescribed disease PD (A11)

- Vibration - induced White Finger PD A 11, 1985
- Carpal Tunnel Syndrome PD A12, 1993
- Sensorineural component added A11, 2007
- Dupuytren's Contracture PD A15, 2018

What are the surveillance options?

- **Short survey**
  If no symptoms review one year
- **Full symptom questionnaire**
  + Past Medical History
  + Full occupational history
  + Examination and ‘diagnosis’
- **Full assessment and standardised tests**
  When employment decisions to be made

Short survey questionnaire example

Have your fingers gone white on cold exposure?

Have you had any tingling of the fingers after using vibrating equipment?

Have you had tingling of the fingers at any other time?

Do you wake at night with pain, tingling, or numbness in your hand or wrist?

Has one or more of your fingers gone numb?

Are you experiencing any other problems with the muscles or joints of the hands or arms?

Do you have difficulty picking up very small objects e.g. paperclips?

Full questionnaire HSE L140

Tiered health surveillance HSE L140

- Tier 1- Initial or baseline; self assessment questionnaire (positive go to tier 3)
- Tier 2- Annual (screening); self assessment questionnaire, responsible person
  (positive go to tier 3)
- Tier 3- Qualified person (OHA,OP)
- Tier 4- Diagnosis (OP)
- Tier 5- Standardised tests

Site of damage: receptors or nerve Trunks QST & NCS

		CNS	PNSMy	PNSMy	PNSMy	PNSUn	Recep	Recep	Recep
Tier	**Test**		**A α**	**A β**	**Aδ**	**C**	**Meissner**	**Pacinian**	**Merkel**
3/4	**Monofil***	X		X					X
3/4	**2-point***	X		X			X		
5	**VTT* 31.5 Hz**	X		X			X		
5	**VTT* 125Hz**	X		X				X	
5	**TA Hot***	X				X			
5	**TACold***	X			X				
5	**NCS**		X CMAP	X DSL					

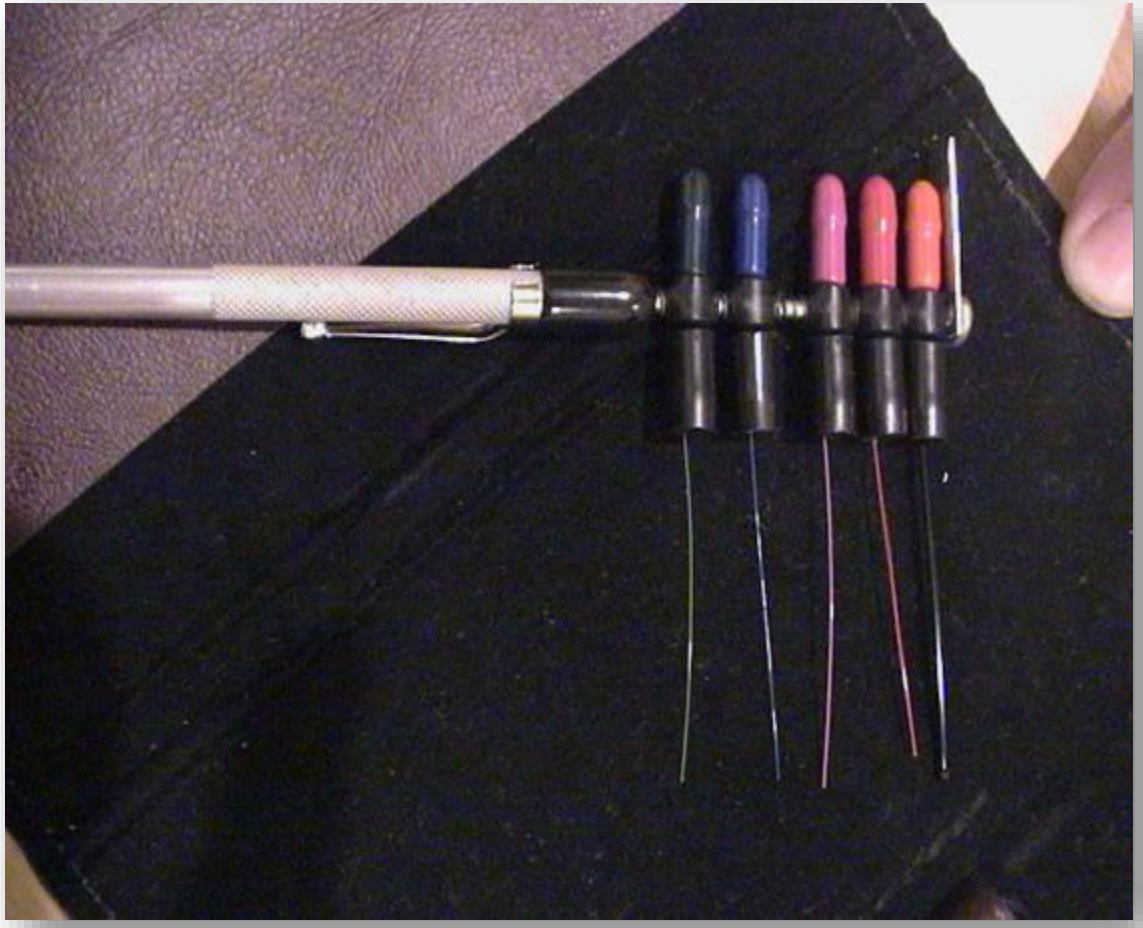
NCS: Nerve conduction studies, *QST: Qualitative Sensory Testing, CNS: Central Nervous System, PNS: Peripheral Nervous System, My: myelinated fibres, A, Un: un-myelinated C fibres, Recep: peripheral receptors, Monofil: monofilaments, VTT: vibrotactile thresholds, TA: thermal aesthesiometry, DSL Distal sensory latency, CMAP: compound motor action potential, X: nerve fibre or mechanoreceptor location being tested

Investigations and Standardised Tests

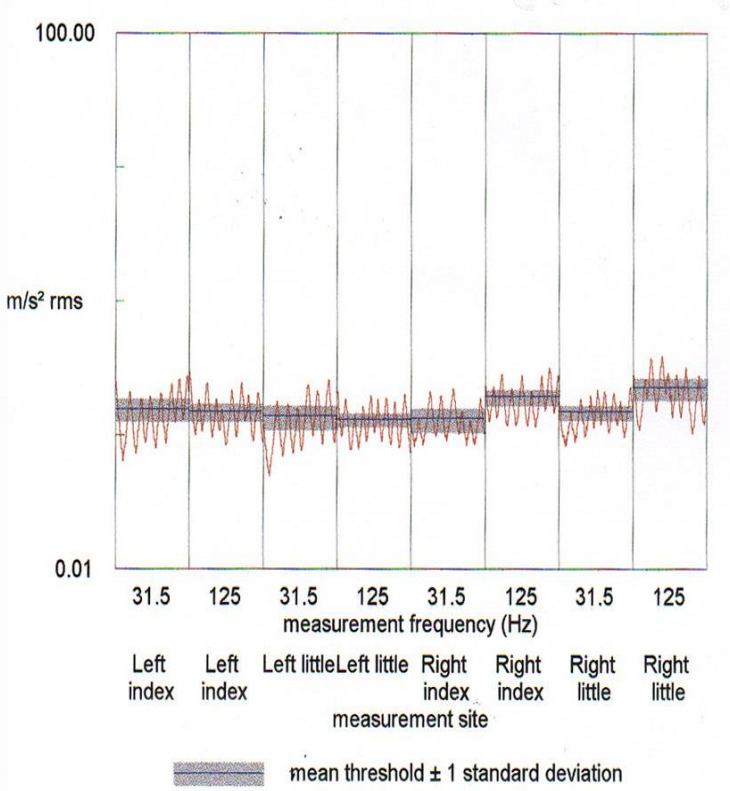
- Jamar hand grip dynamometer- grip strength
- Perdue Pegboard – dexterity
- Monofilaments
- Vibrotactile thresholds - sensory perception
- Thermal aesthesiometry- sensory perception
- Cold water provocation- vascular response
- Finger systolic Blood pressure- vascular response
- NCV (Nerve conduction velocity; POC).

Perdue Pegboard Test, PPT

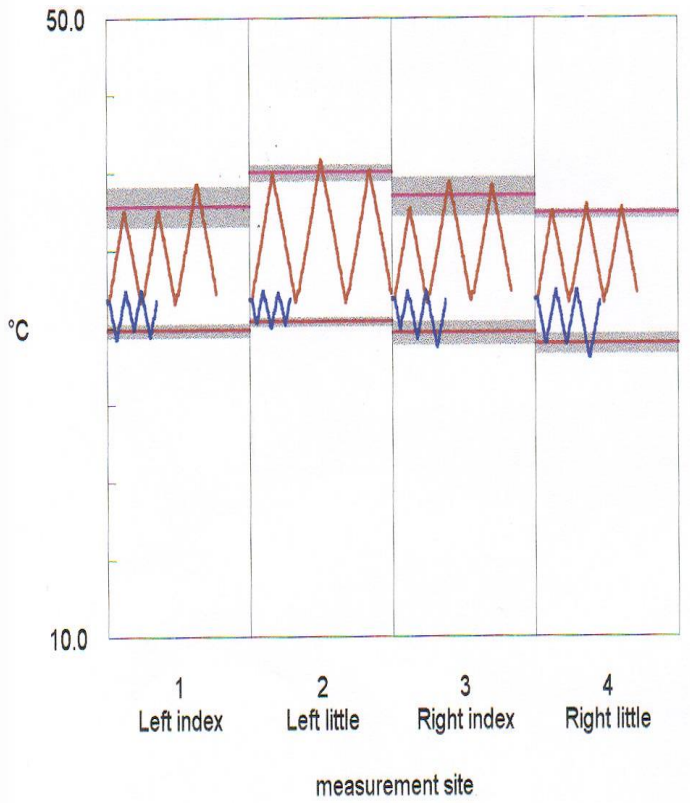
WEST monofilaments and HAVS: N, DLT, DPS, LPS, LPS(D)



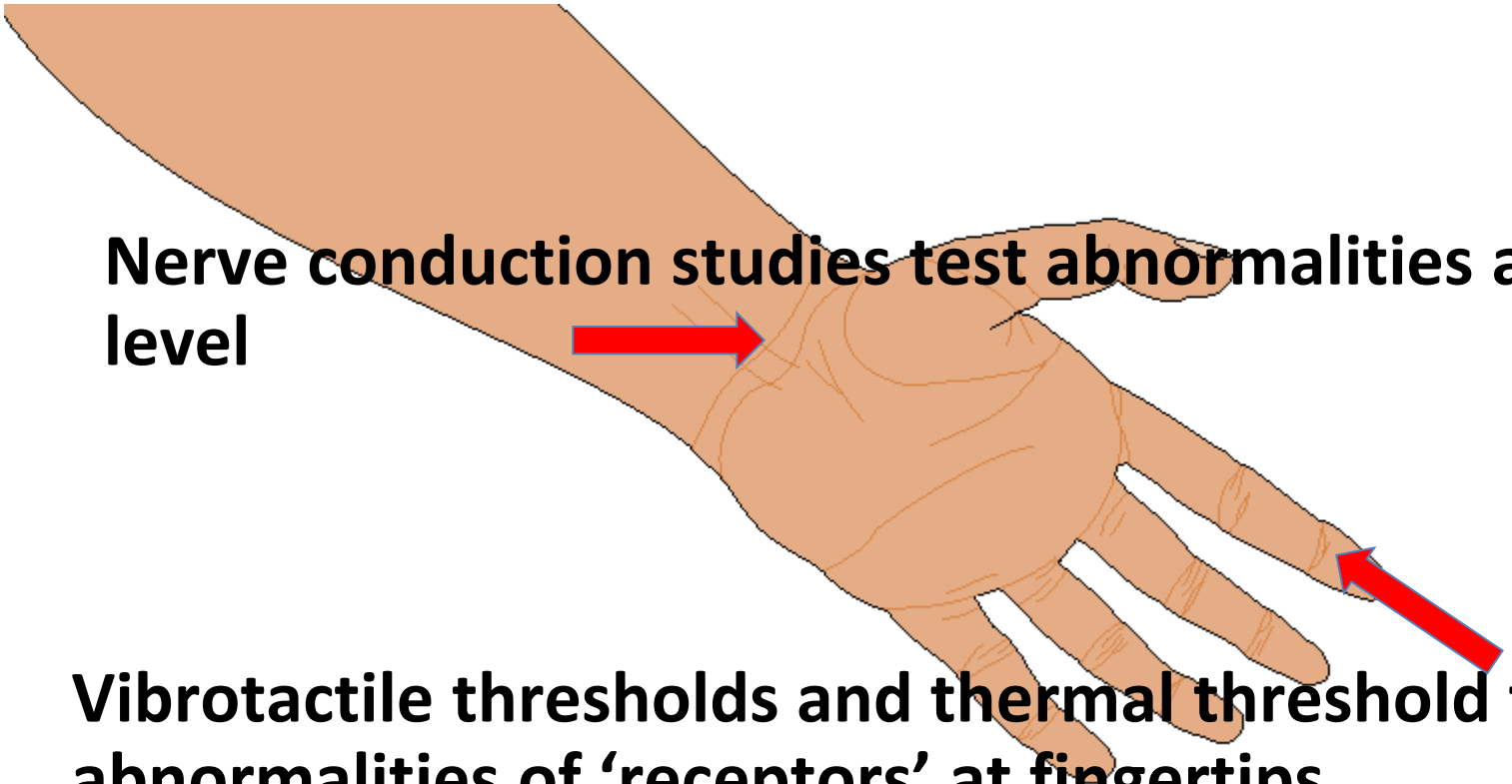
Sensorineural tests, Vibrotactile Thresholds VTT



Thermal Aesthesiometry, TA



Requirement to test receptors and pathways

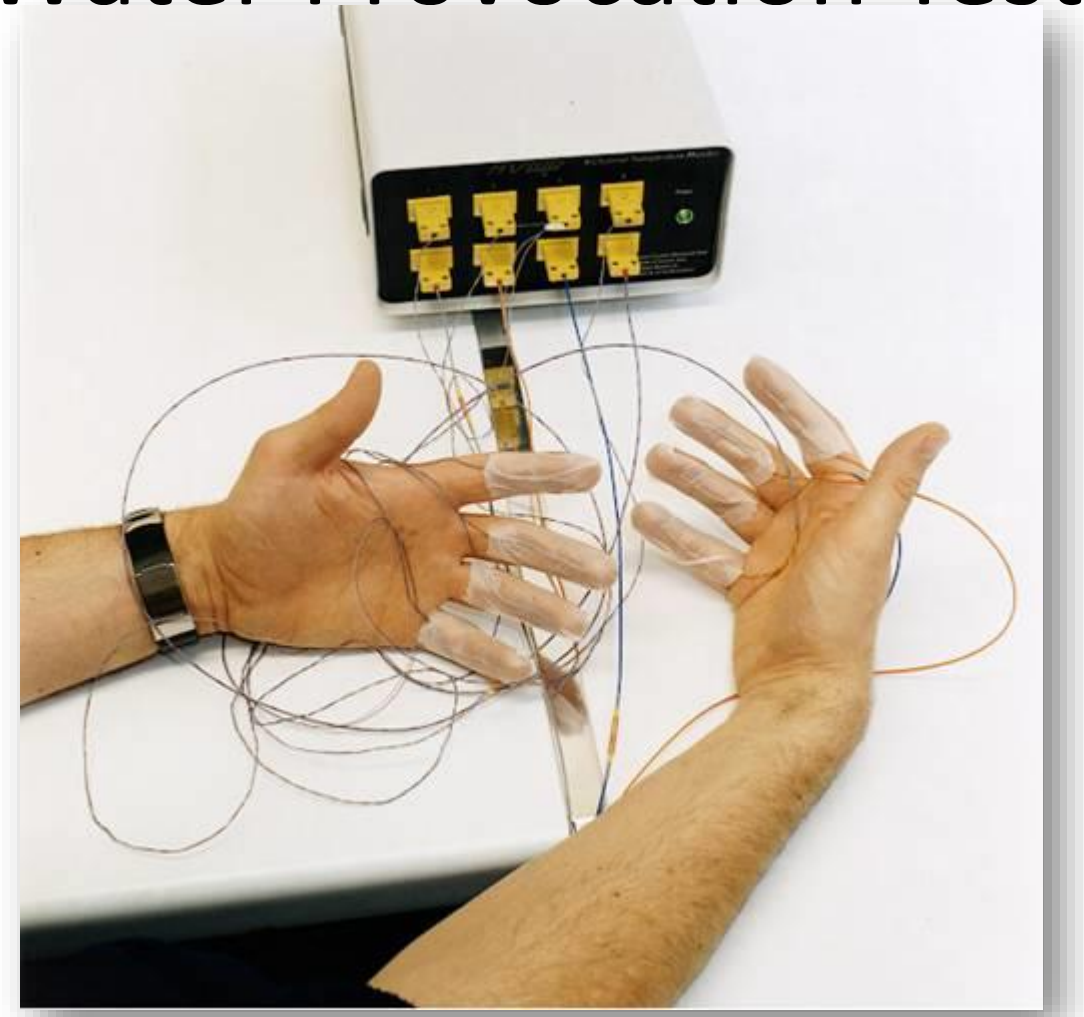


Nerve conduction studies test abnormalities at wrist level

Vibrotactile thresholds and thermal threshold test abnormalities of ‘receptors’ at fingertips

Nerve conduction studies (POC i.e. Neurometrix)

Cold Water Provocation Test, CPT

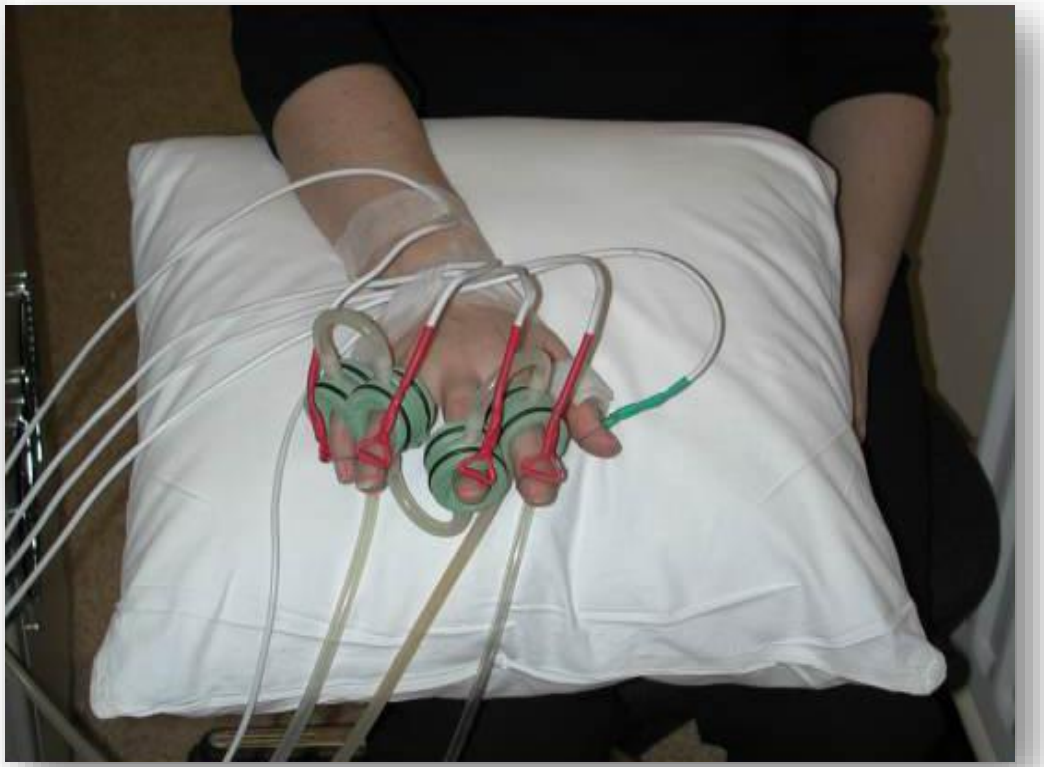


CPT

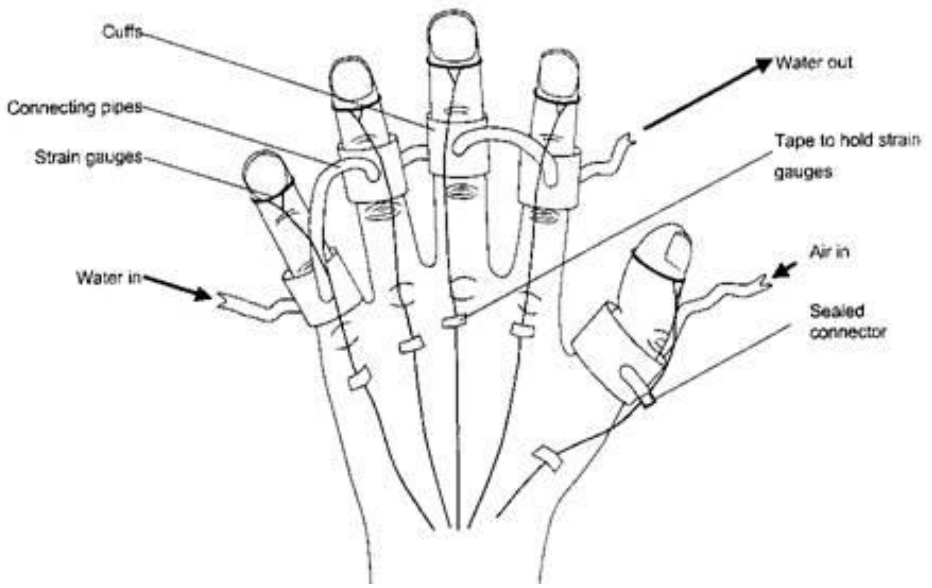
- Administrative Court Judgement 2003 R .v. Secretary of State for Work and Pensions – not to be used to support a negative diagnosis

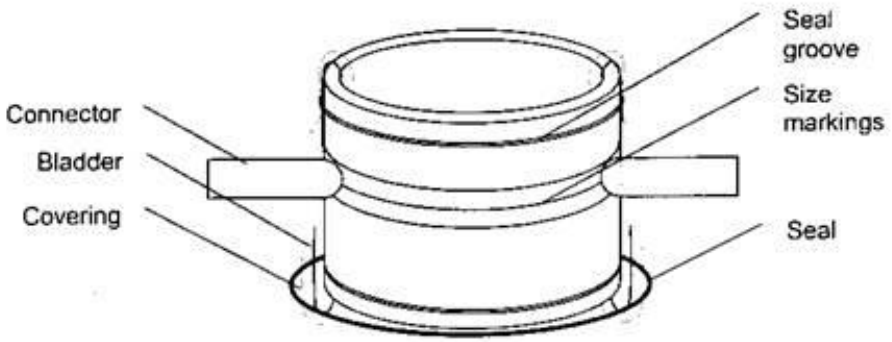
- Large volume study ex-miners -questioned value in diagnosis (Proud G, Burke F, Lawson I.J et al, British Journal of Surgery 2004)

Finger Systolic Blood Pressure

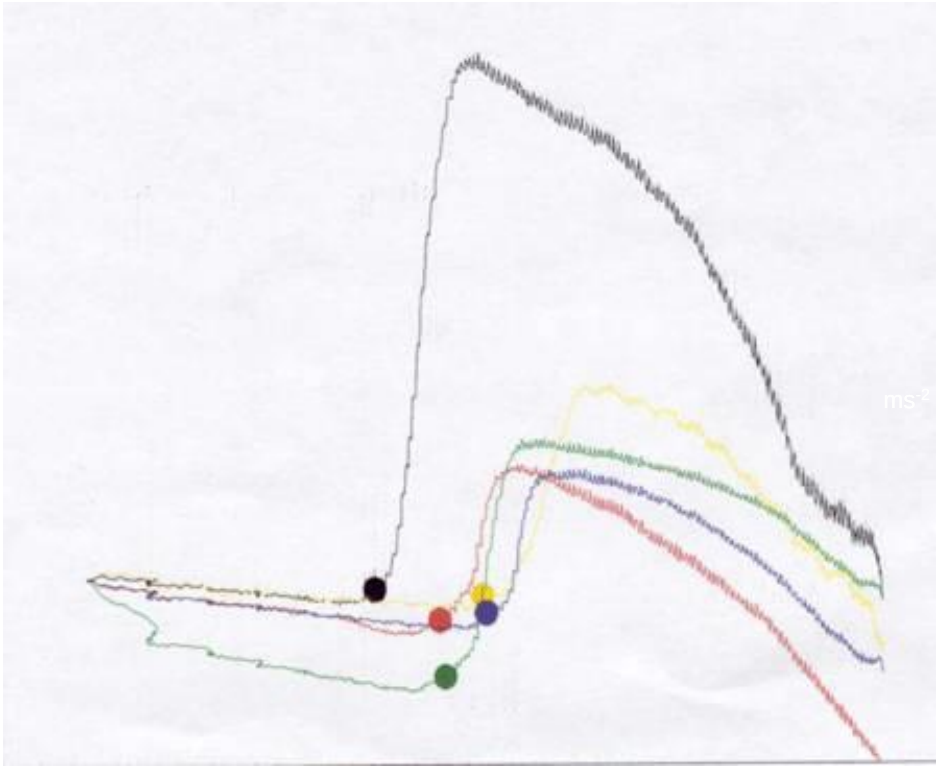


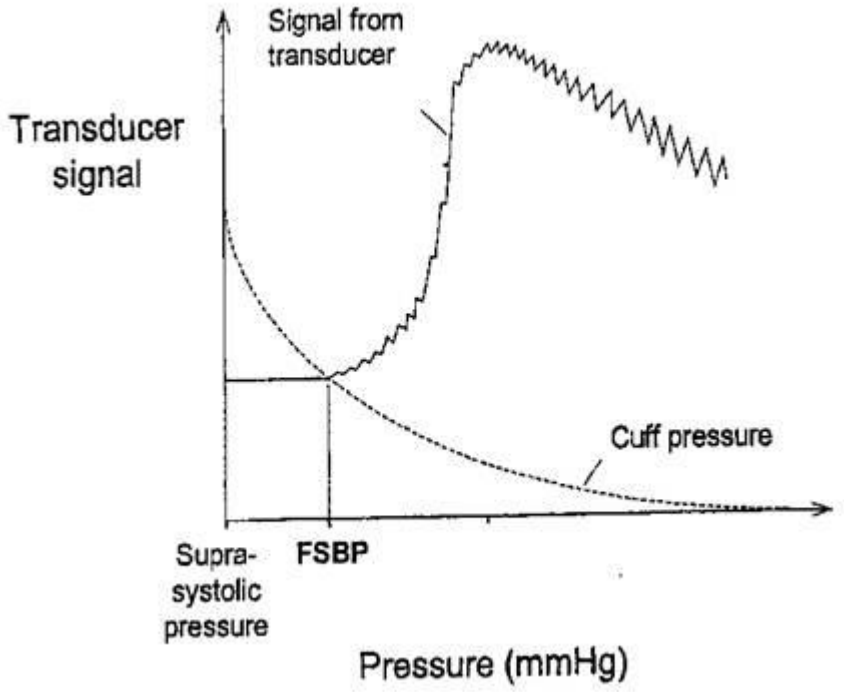
Finger systolic blood pressure





Finger systolic blood pressure





Vascular Tests

(References in FOM review, 2004, Mason; Poole 2009, and other reports in literature)

Test	ISO	Sensitivity%	Specificity%	Comment
FST(CWPT)	Yes	49-73.9	43-94.6	No longer used
FSBP	Yes	44-96	78.3-95	Confirm?

'FSBPs had sensitivities and specificities >90% in fingers reported to suffer blanching'. Ye Y, Griffin MJ. *Occup Environ Med* 2016;73:701-708

Mobile phone

Sensorineural Tests (References in FOM review, 2004, Mason; Poole 2009, and other reports in literature)

Test	ISO	Sensitivity%	Specificity%	Comment
VPT(VTT) 125Hz	YES	35-80	80-94	staging
TNZ(TA)	YES	52-57	70-98	Early?/staging

VTT and TNZ not diagnostic : useful when combined for staging purposes as no individual test 'better' than the other

HSE Guidance (L140, 2019)

HAVS

- Diagnosis of HAVS - advice on fitness for work.
- Continuing exposure acceptable in early cases of HAVS.
- Aim to prevent HAVS stage 3 developing - significant loss of function.
- Onset of HAVS stage 2 - increased frequency of health surveillance.
- Management of existing cases of stage 2 and stage 3 - depends on the rate of progression and stability of symptoms.
- Fitness for work decisions should take account safety issues and availability of other work.

CTS

- If v-CTS diagnosed may need to be removed from exposure. ? Early cases. Return to work after surgery made on an individual basis.

Dupuytren's

- Record early cases (nodules etc). Fitness functional and safety issues.