



Research Article

HAND-ARM VIBRATION SYNDROME

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ABSTRACT

Dentists are shown to have a high frequency of finger-related and other upper limb symptoms and a high prevalence of osteoarthritis in the distal inter-phalangeal joints. Work related vibrations are significant health hazards, which may have a number of serious consequences. The danger to the organism results from the transfer of mechanical vibrations from the equipment of the body. The vibrations are felt both directly at the point of application and indirectly through the whole body of the operator.^[1,2]

This article discusses characteristics of mechanical vibration, mechanisms of vibration syndrome, multifactorial etiology of the syndrome, clinical assessment, laboratory investigations and classification of disease severity and strategies for the prevention and treatment of the syndrome.

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INTRODUCTION

Hand-arm vibration (HAV) is defined as the transfer of vibration from a tool to a worker's hand and arm^[3]. Hand-arm vibration syndrome (HAVS) is a complex, potentially disabling condition comprising of one or more specific neurological, vascular and musculoskeletal features, associated with exposure to hand-held vibrating tools. It is a potentially incapacitated condition comprising of one or more specific neurological, vascular and musculoskeletal features, associated with exposure to hand-held vibrating tools. Most of the studies show a positive association between high level exposure to HAV and the vascular symptoms of HAVS. The risk is greatest in occupations using pneumatic drills, grinders and impact wrenches, with an incidence as great as 70% in these high risk groups.^[4]

Table 1 Risk factors for the development of HAVS

Occupational risks	Non-occupational risks
Hours of use	Individual susceptibility
Cool and cold climate	Smoking
Acceleration of tool	Non-occupational vibration exposure
State of tool maintainence	Previous hand injury
Grip force required	Diabetes mellitus
Handle design	Arthritis
Posture	
Rest breaks	

Etiology

1. It is caused by working with vibrating tools. It is unusual to develop hand-arm vibration syndrome unless one has used vibrating tools for at least ten years.
2. Use of - Ultrasonic instruments
 - a. Piezoelectric instruments

Micromotor

Pathophysiology

The dominant frequencies for vibration damage to occur are 25-320Hz. Vibration can be divided into general and local. The latter causes negative effects in the upper limbs, especially when the hands are holding the instruments or processing and element^[3,4]. Mechanical vibrations affecting the organism through the upper limbs causes changes in the vascular, neural and osteoarticular system^[5,6,7,8]. This phenomenon of such changes and exposure to vibrations surpassing frequencies safe for the organism may lead to an occupational disease called the vibration syndrome. When the temperature of the environment falls, hypersensitivity to cold occurs as well as paroxysmal blanching of one or more fingertips also occurs. Paroxysmal circulatory disturbances in the fingertips are described as Raynaud's phenomenon, 'dead fingers' or the 'vibration white finger'.

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Hand arm vibration syndrome reveals three major pathological changes

1. Intense thickening of muscular layers of artery wall with individual muscle cell hypertrophy
2. A peripheral demyelinating neuropathy with increased number of Schwann cells and fibroblasts
3. Increased amounts of connective tissue causing perivascular and perineural fibrosis^[9]

A model of the proposed multifactorial etiology of hand arm vibration syndrome based on current hypothesis is presented. Autonomic dysfunction-^[10-18]

A reflex central sympathetic hyperactivity and parasympathetic depression initiated by over stimulation of Pacinian corpuscles, is been implicated in the pathogenesis of hand arm vibration syndrome. This central reflex mechanism theory is held up by single hand vibration inducing contralateral vasoconstriction, by proximal nerve blockade decreasing abnormal vasoconstrictor response, and by raised urine and plasma catecholamine levels in hand arm vibration syndrome sufferers.

Local vasoregulatory abnormalities-^[19-25]

It is said that selective alpha-1 adrenoreceptor damage may occur resulting in a comparative predominance of alpha-2 adrenoreceptors and an abnormally strong vasoconstrictor response. Decreased or inhibited endothelial-mediated vasodilatation and increased platelet adherence, activation and degranulation with release of vasoconstrictors and mitogenic factors have been suggested in the exaggerated smooth muscle vasoconstriction and hypertrophy seen within the digital arterial wall of this syndrome sufferers.

Peripheral nerve and receptor dysfunction-^[26-29]

Vibration results in increased peripheral oedema and increased pressure within the nerve; simultaneously sensory and motor conduction velocities are decreased. The first to be affected are the fast adapting type II receptors with reduction in sensation at frequencies of 125-250Hz, followed by more severe cases by loss of sensations at all frequencies above 60Hz.

Table 2

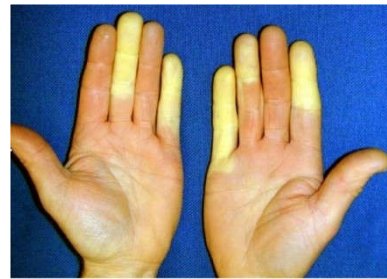
Receptor	Type I (responds to sharp contours)	Type II (responds to diffuse contours)
Slow adapting	Merkel's cell linked	Ruffini's corpuscle linked
Fast adapting	Meissner's corpuscles linked	Pacinian's corpuscle linked

Clinical Features

HAVS is a complex condition, which consists of various neurological, vascular and musculoskeletal symptoms. The period of time between exposure to vibration and the development of symptoms is variable. The latency period is short in high risk groups (Palmeir and Taylor, 1994).Symptoms are initially intermittent but with time and the progression of the disease, they may become continuous if exposure is not limited to an early stage. In HAVS the phenomenon is typically asymmetrical and affects the dominant hand first.

Vascular symptoms

The classic vascular manifestation is that of finger blanching on exposure to cold, often damp conditions commonly referred to as vibration white finger (VWF).Blanching is often accompanied with numbness and decreased sensitivity. These are attack are common in morning because of the low metabolic activity rate and is seen more in winter. If the vibration exposure still persists the attacks are commonly seen occurring in all seasons. Attacks may last from 1-60 min and generally resolve when the sufferer warms their hand. Rewarming is commonly associated with hyperemia and pain. These features are similar to those of Raynaud's phenomenon, but VWF is usually asymmetrical with thumbs getting affected at the last. Initially these changes are localized to the fingers which are exposed to the vibrations(trigger finger) but ultimately with prolonged vibration exposure all digits from the tips to metacarpophalangeal joints may become affected. Palms are rarely affected. Ultimately fingers appear cyanotic and rarely develop trophic or gangrenous leading to amputation.(Palmeir and Taylor,1994)^[30]



Pic 1 vibrations induced white finger

Neurological symptoms

Sensory changes are common especially tingling, paraesthesia, sensory loss and decreased dexterity. They are worse in dominant hand. Decreased sensory and temperature perception are common symptoms. Initially these changes are common but on prolonged exposure to vibration they become continuous and reversal of these symptoms are less likely on discontinuing the vibration exposure. Motor changes also occur with decreased muscle strength and reduced manual dexterity.

Musculoskeletal symptoms

Musculoskeletal complication such as osteoporosis of the wrist, elbow, acromioclavicular joint have been reported following prolonged vibration exposure(Hagberg 2002). Repeated jerking and agitation of joint movements lead to synovial damage associated with higher incidence of wrist and proximal joint symptoms.

HAVS and carpal tunnel syndrome

Carpal tunnel syndrome (CTS) is an entrapment syndrome caused by the pressure on the median nerve within the carpal tunnel. Carpal tunnel syndrome with its typical features of median nerve damage, with tingling sensation, numbness, loss of sensory perception and Sympathetic Skin Changes in the distribution of Median Nerve classically occurring at night is one of the main differential diagnosis for HAVS.^[31,32]

Table 3

History/symptoms	HAVS	HAVS/CTS	CTS
Exposure to vibration	Yes	Yes	No
Exposure to repetitive strain	No	Yes	Yes
Finger numbness	Yes	Yes	Yes
Tingling			
Median	Yes	Yes	Yes
Ulnar	Yes	Yes	Rarely
Sleep disturbance	Unusual	Common	Common
Muscle cramps	Common	Common	Unusual
Aches and pains in arms	Common	Common	Unusual
Grip strength reduced	Yes	Yes	Unusual
Raynaud's phenomenon	Yes*	Yes*	No

*may not be apparent to patient in early stage

Examination

Thorough physical examination is essential giving importance to neck, upper limbs and hands noting restricted movement, muscle wasting, and scars. Careful cardiovascular and neurological examination is a must. Upper radial pulses (radial and brachial) should be palpated and blood pressure should be noted of both the arms. The fingers are inspected for any discoloration, signs of ischemia, and examined for temperature. Examination of sensation, including pin prick and upper extremity strength including grip strength should be performed. Adson's test to detect thoracic outlet syndrome accompanied by compression of subclavian artery obstruction, Lewis-prusik test for assessment of capillary circulation, Allen test for patency of palmar arches and the digital arteries and Phalen's test and Tinel's sign for carpal tunnel syndrome should be performed. Palmar thickening and finger contractures should be noted.

Investigations

History of occupational exposure to vibration and presence of suggestive symptoms in absence of any other cause gives a diagnosis for HAVS. To rule out other causes of Raynaud's phenomenon, complete blood count(CBC), erythrocyte sedimentation rate(ESR), urea and electrolytes, liver and thyroid function tests, rheumatoid factor, measurement of antinuclear antibody, Vit B12 and red blood cell folate levels should be performed.

Neurological testing – as there is no standard test for the assessment of neurological symptom severity, number of tests have been described

1. Peripheral nerve conduction study to assess severity of neuropathy. Median and ulnar nerve is involved in HAVS whereas in Carpal tunnel syndrome only median nerve is involved.
2. Pressure perception test using Semmes-Weinstein monofilaments over six areas(3 assessing median nerve and 3 assessing ulnar nerve). A maximum score of 30 is present for each hand. A score more than 25 indicates diminished light touch.^[34]
3. Current perception threshold which give the results depending on the current used assessing the vibration or temperature perception.

4. Vibration perception threshold test uses frequency of 8-500 Hz and it is reduced in patients with HAVS.
5. Thermal perception threshold test shows perception is reduced in patients with HAVS.^[35]

Serological testing

Soluble Thrombomodulin (sTM) and soluble inter-cellular adhesion molecule-1 (sICAM-1) are endothelial cell surface receptors and are increased in patients with HAVS as a result of endothelial cell damage.^[36,37]

Classification

Table 4 The Taylor-Pelmeare scale^[33]

Stage	Condition of digits	Work and social interference
0	No blanching of digits	No complaints
0T	Intermittent tingling	No interference with activities
0N	Intermittent numbness	No interference with activities
1	Blanching of one or more fingertips, with or without tingling and numbness	No interference with activities
2	Blanching of one or more finger, with numbness; usually confined to winter	Slight interference with home and social activities, no interference at work.
3	Extensive blanching; frequent episodes in summer as well as winter	Definite interference at work, at home, and with social activities; restriction of hobbies
4	Extensive blanching: frequent episodes in summer as well as winter	Occupation changed to avoid further vibration due to symptoms

Table 5 Stockholm workshop scale; each hand is/should be graded separately

- A) Classification of cold-induced Raynaud's phenomenon in HAVS
- B) Sensorineural stages of HAVS

Stage	Grade	Description
0	None	No attacks
1	Mild	Occasional attacks affecting the tips of >1 finger
2	Moderate	Occasional attacks affecting distal and middle(rarely proximal) phalanges of >1 finger
3	Severe	Repeated attacks affecting all phalanges of most fingers
4	Very severe	As in stage 3,with trophic changes in the fingertips

Stage	Description
0SN	Exposed to vibrations but no symptoms
1SN	Intermittent numbness with or without tingling
2SN	Intermittent or persistent numbness, reduced sensory perception
3SN	Intermittent or persistent numbness, reduced tactile discrimination or manipulative dexterity

SN- sensorineural

Management

Prevention

The responsibility for the prevention of hand arm vibration syndrome lies with employers, manufacturers of tools and dental professionals. Potential sufferers should be advised and counselled appropriately. The following are usually advised-

- Smoking- It makes symptoms worse. The chemicals in tobacco cause vasoconstriction. If smoking is stopped completely it may ease the problem.
- Avoiding some chemical agents/drugs- Some medications like beta-blocker, anti-migraine medicines, decongestants should be stopped immediately if symptoms persists. Other drugs like caffeine(in coffee, cola and in some medicines) trigger symptoms in some people. Cutting out on caffeine for a few weeks/months may help to improve the condition. Amphetamines and cocaine may also trigger the condition.
- Try to keep hands warm in cool weather/environment- Try to keep your hands warm by wearing hand gloves out in cool weather. Try to keep whole body warm although hands are important, symptoms are less likely to occur if entire body is warm. If symptoms are severe or easily triggered, portable heat packs and battery-heated gloves are useful.
- Try not to touch cold objects- Use a towel or gloves when removing food from the freezer or when working with cold food.
- Regular exercise- Exercise is a must everyday as it improves the peripheral circulation.
- When a bout of symptoms develops, warm the hands as soon as possible. Soaking the hands in warm running water is the best remedy to warm up the hands(take care that water is not too hot).



Pic 2 Battery heated gloves

Treatment

The main line of treatment consists of abstinence from vibration exposure.

Physical remedies like physiotherapy has been proved to give good results.

Baleno in Latin means bath. This therapy involves hot water massage, relaxation and stimulation through moving water.

Chemotherapeutic agents include

1. Calcium antagonists- nifedipine and diltiazem have shown to improve subjective symptoms.^[38]
2. Alpha- adrenoreceptor antagonists- Thymoxamine blocks peripheral vasoconstriction in the skin and hence is a first-line of treatment.
3. Fibrinolysis- Stanozolol a synthetic steroid derived from testosterone enhances fibrinolysis and is shown to reduce blood viscosity.
4. Prostanoids- Prostaglandin E₁, prostacyclin reduce platelet adhesiveness and cause vasodilatation.

5. Cervical sympathectomy- It is a procedure done to cut or block a nerve in the middle to treat the problems like extreme sweating,pain etc. This procedure gives only temporary relief and is not commonly used in practise.^[39]

Limiting Exposure to Vibration for Dentists

The Dentists are obligated to use efficient machines, which should be periodically checked and serviced in accordance with the producer's instructions. Minimizing clearance, improving the balance and eliminating the collision of moving parts in the dental machines will lead to a decrease in noise and vibration levels. While purchasing new equipments care should be taken that it does not create more noise and vibrations than the old one. Regular check-ups should be carried out giving prime importance to vascular, neural and osseous systems of the upper limbs. It is important to select the right kind of protective gloves which do not restrict hand movements, which could affect negatively on the vascular system. Only dry protective gloves should be used. In between surgeries if gloves become wet, they should be replaced by new pair of gloves after thoroughly washing and drying hands. Hands must be protected from loss of heat. Depending on the temperature and humidity of the environment, the gloves should be properly insulated. Hand exercises in between long dental procedures should also be practised.

CONCLUSION

Hand-arm vibration syndrome is a complex condition wherein assessment and validation of symptoms is filled with complications. Risk reduction, prevention and early detection of symptoms gives the best chance of symptomatic control and it is the duty of health professionals to be alert to HAVS. It is important for dentists, physiotherapists, occupational therapists to be aware of this condition so as to identify the difference between HAVS and Carpal tunnel syndrome.

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