Peripheral neuropathy: Challenges, solutions and applications

Symptoms of peripheral neuropathy, which normally affects hands and feet, can range from numbness and heaviness through to painful tingling, burning and stabbing. The impact can be mild or it can be disabling, for example people with peripheral neuropathy in their hands may lose their dexterity and find it hard to pick up or hold things and damage to sensation in the feet can affect balance. Losing feeling can also mean that people don't notice cuts, burns or blisters, so that injuries go untreated or become infected.

One of the most common causes of peripheral neuropathy is type 1 and type 2 diabetes, where high levels of blood glucose damage the peripheral nerves. Diabetic neuropathy can also affect nerves in the gut, urinary tract, blood vessels and heart.

Peripheral neuropathy is a common side-effect of chemotherapy when treating cancer. Certain types of chemo drugs cause damage to the nervous system, causing chemotherapy induced peripheral neuropathy (CIPN).

The symptoms of CIPN include pain, numbness, tingling sensations or paresis, which may have major impact on a patient's quality of life. Ordinary daily chores such as buttoning of shirts, tying of shoelaces or cooking may become cumbersome or impossible. Careful surveillance of neuropathy during chemo treatment is therefore important to allow modification of the dose or type of active substance.

Another common cause of peripheral neuropathy is hand-arm-vibration syndrome (HAVS). This results from regular use of tools, which may cause minor but repeated injuries to blood vessels and nerves. HAVS can affect people who work in construction, sheet metal work, car repair, welding, tree felling, carpentry, road maintenance, and electrical work, and even dentistry and podiatry, where the tools are much smaller but the frequency of vibration is higher.

Because these injuries tend to be seen in people of working age, this has an impact on working life and on families as well.

Other causes of peripheral neuropathy include:

- Kidney disease
- Multiple Sclerosis
- Hypothyroidism
- Chronic inflammation
- Vitamin and mineral deficiencies
- Infections and autoimmune disease
- Poisoning
- Nerve trauma
- Side effects from common medication: antihypertensives, e.g. statins, antibiotics or anticonvulsants

VibroSense Meter® II

Challenges in diagnosis and treatment

Diagnosis of peripheral neuropathy and HAVS currently rely on a variety of different techniques. Many of these are used together and in combination with clinical assessment techniques based on rating according to predefined scales.

The Toronto Clinical Neuropathy Score (TCNS) is commonly used to determine the severity of diabetes neuropathy based on symptoms, and scores of sensory and reflex tests. Similarly, the Stockholm Workshop Scales (SWS) have been utilized in the field of HAVS for more than 30 years, but with focus on both criteria for vascular and sensorineural staging.

One of the commonly-used approaches is testing for the sensation of vibration with a tuning fork. The fork is struck and applied to the skin, and then damped, and the patient reports on when vibration starts and stops (the on-off method), or the vibration is allowed to die away and the patient reports when he or she can no longer feel the vibration.

Other techniques include asking the patient whether they can feel touches from a monofilament (Semmes-Weinstein mono-filament examination or SWME), or superficial pain from a pin prick [1]. While these are standardised as much as possible, there will be some degree of operator influence, and the results are qualitative not quantitative

A biothesiometer is effectively an electronic tuning fork, where the intensity can be turned up and down. However, this only operates at a single frequency [2]. Electrodiagnostic tests include electromyography (EMG) and nerve conduction velocity (NCV) testing [3], but these are quite specialist tests and require expert interpretation, and they can be painful.

Once the symptoms of neuropathy are seen, the damage is generally irreversible. Treating existing peripheral neuropathy is about relieving the signs and symptoms, for example pain killers, anti- seizure medications, antidepressants, and topical treatments such as local anaesthetics or capsaicin. Transcutaneous electrical nerve stimulation (TENS) may also help, but these won't stop the progress of the neuropathy.

The best approach is to find the very early signs of nerve damage before the symptoms appear. This then allows people to take steps to reduce their risk. In diabetes, this could be a signal to control the disease more tightly through diet, exercise and drugs. With HAVS, it could mean changing tools and techniques at work, or even moving to another role. In chemotherapy, modification of the treatment regimen in due time, could spare cancer patients unnecessary nerve damage.

Creating the VibroSense solution

As a response to the diagnostic challenges, VibroSense Dynamics has developed the VibroSense Meter®, a quantitative and operator-independent sensory test tool for diagnosing impaired sensitivity and peripheral sensory neuropathy in the hand and foot.

This is a CE-marked medical device, and is currently on the market in Scandinavia. Its development started with Göran Lundborg, a professor at the Department of Hand Surgery in Malmö/Lund. He was frustrated by seeing patients in his clinic who had symptoms of peripheral neuropathy, but he had no effective ways to diagnose them and track their level of nerve damage. In the 1980s, his group started to develop a diagnostic method based on MultiFrequency Vibrometry (also known as multifrequency tactilometry), which eventually became the VibroSense Meter®.

Peripheral neuropathy can result from damage across the range of nerves and mechano-receptors, and these respond to different frequencies of vibration. To ensure that damage is measured across all the nerves and receptors, unlike other diagnostic techniques, the VibroSense Meter uses mechanical vibrations between 4 Hz and 500 Hz.

The patients place their hand or foot on the device and, in a similar way to a hearing test, report the intensities of the applied frequencies that they can and cannot feel. The test, which only takes three to four minutes per test site, can also look at responses from different combinations of receptors by varying and combining frequencies of vibration.

The meter links to a computer, which creates numerical scores in a 'Vibrogram'. This maps the patient's sensitivity graphically to vibration and compares it against an age- and gender- matched reference based on 1100 healthy individuals. The vibrograms are stored in a patient database and can be compared with previous tests carried out over a period.

To ensure standardisation between operators and between tests, the meter controls for the pressure applied by the patient during the assessment, and measures the temperature of the skin each time the test is carried out.

Applications for the VibroSense Meter

The VibroSense Meter was launched in 2007, and is currently used in diabetic care, occupational health and environmental medicine clinics and in hospitals for the diagnosis and prevention of peripheral neuropathy and vibration injury, and by researchers in basic biology and drug development.

In the workplace, the VibroSense Meter can be used to screen people before they start working in potentially risky environments to determine a baseline, and then use it to monitor any changes, or assess preventive measures. Because it can pick up the changes in the nerves and mechanoreceptors before symptoms emerge and the damage becomes irreversible, this allows the employee and employer to work together to make changes in the workplace, for example changing to low-vibration tools, improving tool maintenance, modifying work patterns, wearing warm clothing to improve circulation, or even changing roles.

The technology also has a role in diagnosing nerves that are trapped or compressed, for example measurements of the sensitivity in all four fingers can be used to diagnose carpal, radial and cubital tunnel syndrome. Follow-up measurements post physiotherapy or surgery can monitor the improvement of treatment approaches.

Diabetes

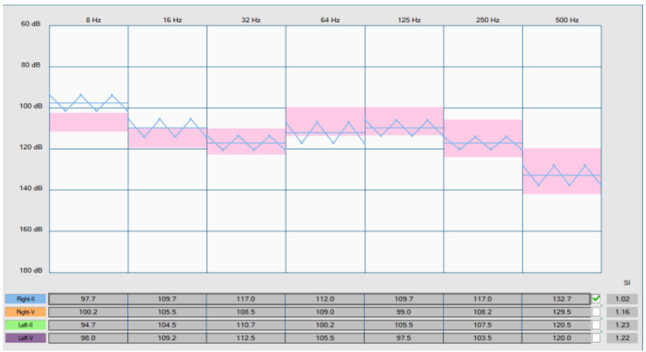
In diabetes, healthcare professionals can use the meter as a diagnostic measure tool to discover sensitivity impairments long before the patient experiences symptoms, making it possible to intervene with preventive measures like optimizing glucose control and exercise. With regular check-ups, the VibroSense Meter can be a vital tool to make the patient aware of the effects of the impact of lifestyle changes and medication adherence. It can also be used to provide objective reassurance in concerned patients.

Chemotherapy

The meter can also play an important role in basic research, to understand why the changes occur in different diseases, and in drug development, to create therapeutics that could prevent and treat the onset of neuropathy. As an example, chemotherapy in cancer can have neuropathy as a side effect, and this can limit otherwise effective treatment regimens. The VibroSense technology could be used in research to monitor the side effects of the chemotherapy or test the efficacy of potential neuro-protective agents.

It could also be used during treatment to decide when patients should stop receiving neurotoxic chemotherapy, as this is likely to vary from patient to patient.

The VibroSense Meter® II device was launched in July 2018. This new device manages examination of both hand and feet. Further development will determine characteristics of vibrogram levels that are the most relevant to support preventive measures and treatment of diabetes and cancer.



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