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Newton, Veronica

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# NEUROPATHY: PAIN DAMAGE AND THE DIABETIC FOOT

Neuropathy, or the impairment of nerve structures and function, is a common complication in diabetes and affects up to one-third of patients. The most common manifestation is the loss of pain sensation and this can lead to unrecognised trauma injuries and the development of ulceration. This article looks at the aetiology of neuropathy and details management strategies.

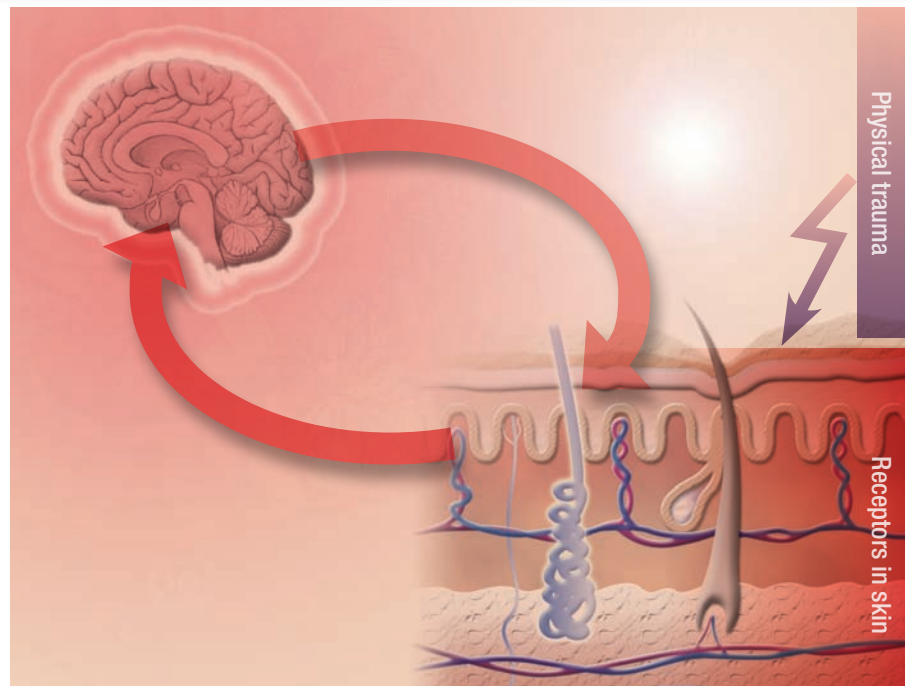
Veronica Newton is a Senior Lecturer in Podiatry, Centre for Health and Social Care Research, University of Huddersfield

The sensation of pain is caused by physical trauma, such as cuts, tears or burns, and is dependent on the activation of neurones (nerve cells) in the skin, spinal cord and cerebral cortex of the brain.

The pain pathway (*Figure 1*) involves ascending nerve pathways that deliver information from the trauma site to the brain, which interprets the signals and determines the nature of the trauma. The brain is able to make sense of the information from the ascending nerve pathway and generate an appropriate response, which is then delivered to the site of trauma by the descending nerve pathway. The descending nerve paths then send responses back to the body's periphery (Wilkinson and Lennox, 2005).

## Nerve damage in diabetes

Neuropathy can be defined as the impairment of nerve structures and function. It is a frequent complication in diabetes and can be detected in approximately one-third of all



*Figure 1. Pain pathway. Specific sensory receptors in the skin are activated at the point of trauma to the skin, initiating a message to the brain.*

patients (Boulton et al, 2000), although figures vary between published sources.

**The most common manifestation of diabetic neuropathy is the loss of pain sensation in the peripheries**

The most common manifestation of diabetic neuropathy is the loss of pain sensation in the peripheries, particularly the feet. This is known as painless neuropathy. The lack of pain results in an inability to detect

trauma (and often pain).

Damage ranging from minor skin abrasions to major injury may go either unnoticed or the severity may be underestimated, and if left untreated (particularly on the foot) may ulcerate with possible complications of infection. Acute painful episodes of neuropathy are, however, reported in some patients (known as painful neuropathy).

An appreciation of the aetiology of neuropathy in diabetes (*Table 1*) assists in the understanding and management of the condition.



Figure 2. Typical clinical presentation of foot affected by polyneuropathy.



Figure 3. Painless neuropathic ulcer on the end of the toe.



Figure 4. Painless neuropathic ulcer on the ball of the foot.

In people with diabetes, neuropathy can involve all the different types of nerve fibre:

- ▶▶ Motor
- ▶▶ Sensory
- ▶▶ Autonomic.

Symmetrical distal polyneuropathy, where all the

nerve fibre types are damaged, is the most common form of diabetic neuropathy. This can give rise to an altered foot shape (Figure 2).

#### Altered pain mechanisms in diabetic neuropathy

In neuropathy, normal pain pathways can be impaired due to nerve dysfunction leading to unrecognised trauma and often painless ulceration (Figures 3 and 4). Up to 50% of people presenting at dedicated diabetic foot clinics will also have neuropathy (Edmonds and Foster, 2005) and this can be a huge challenge to healthcare workers.

The risk of amputation in people with diabetes is higher than in the non-diabetic population due to increased likelihood of damage to peripheral nerves and vessels in the lower limb, the figures reported are contentious depending on how the amputation data is recorded and the country of origin of publication.

#### Importance of assessing the extent of diabetic neuropathy

If neuropathy is suspected it is

Table 1

#### Aetiology and risk factors for neuropathy (NICE, 2004)

- ▶▶ Poor glycaemic control — plasma glucose levels of 6–7mmol/l or HbA<sub>1c</sub> of 6–7% are recommended for people with diabetes
- ▶▶ Peripheral vascular disease
- ▶▶ Ethnic background — diabetes appears to be more prevalent in people with south Asian and Afro-caribbean origins, due to lifestyle and dietary factors in addition to increased genetic likelihood
- ▶▶ (Increased) duration of disease

possible to measure a patient's nerve fibre function in order to assess the extent of nerve damage and the risk of trauma (Table 2).

National Institute for Health and Clinical Excellence (2004) guidelines identify the basic foot examinations that should be carried out on people with diabetes:

- ▶▶ Use of a 10g monofilament to assess sensory status
- ▶▶ Palpation of foot pulses
- ▶▶ Inspection of the feet for deformities
- ▶▶ Inspection of footwear for wear and tear and foreign objects that may traumatise the foot.

Basic foot screening tests according to Baker et al (2005) include:

- ▶▶ Monofilament testing — a monofilament is a nylon fibre mounted on a hand-held pen structure. The fibre compresses at a given force when applied to a nominated anatomical area on the sole of the foot informing the practitioner if the person has the ability to feel pressure/pain in those areas

**Table 2**

Summary of nerve function, assessment and clinical presentation of nerve damage

Nerve fibre damage	Normal function of nerves	Mode of assessment to detect damage	Clinical presentation of nerve fibre damage
Motor Sensory	Motor conduction — impulses generated by motor nerves. Some sensory function	Ankle and foot reflexes	Muscle atrophy weakness and abnormal gait patterns
Sensory	Sensory vibration detected	Vibration perception (128Hz tuning fork/biothesiometer)	Inability to detect mechanical forces — for example vibration
Sensory	i) Thermal cooling — ability to detect change in temperature from warm to cool ii) Able to detect sharp pain iii) Pain sensation	i) Temperature ii) Neurotip — ability to distinguish between sharp and blunt iii) Monofilament — ability to feel pressure/pain	Inability to detect sharp pain or pressure or cool temperature
Sensory	i) Sensation of warmth — able to detect increasing warmth or sudden application of heat ii) Dull burning pain	i) Temperature ii) Monofilament	Inability to detect burning pain or warm temperature
Autonomic	Vasodilation of vessels	Ambient foot temperature/foot pulses	Inability to respond to injury — lack of inflammation

applied as a small hand-held probe — the vibration can be controlled and measured as volts (up to 50). A threshold of vibration perception can be documented

- ▶▶ Sharp/blunt testing with a neurotip — the neurotip is a small (single-use) device (2.5cm in length) with a blunt tip at one end and a sharp tip at the other. The ends are randomly applied to nominated anatomical areas on the sole of the foot, informing the practitioner if the person has the ability to discriminate between sharp and blunt sensation in those areas
- ▶▶ Temperature testing — temperature testing can be done simply by the application of the cold mental tuning fork to nominated anatomical areas on the sole of the foot. This informs the practitioner if the person has the ability to identify cold. It is important to note that it is inadvisable to apply heat to the limb especially if neuropathy is suspected as it may cause thermal trauma).

All the above tests require the patient to close their eyes to prevent the use of other senses in the interpretation of messages.

When assessing neuropathy, one of the main problems is the variations that can occur in patient's responses to stimuli (Rahman, 2003). Patients' perception of pain is notoriously difficult to assess due to:

- ▶▶ The subjective nature of pain
- ▶▶ The crossover of nerve function — pain may be interpreted as an incorrect modality, e.g. the person may feel light touch in

**Table 3**

Differential diagnosis of pain in the neuropathic foot

Differential diagnosis	Action
Infection — may be superficial or deep; localised or systemic	Assess and inspect for site and severity of infection — treat with local antimicrobials and/or systemic/intravenous antibiotics
Osseous (bony) fracture or dislocation often with referred pain away from site (Neuroarthropathy or Charcot)	Identify the structures affected and immobilise the area; rest is imperative
Ischaemic often exercise-induced pain or nocturnal pain	Assess vascular supply; pulses, Doppler, and ankle brachial pressure index to test the perfusion of blood to the leg and foot

- ▶▶ Vibration testing with a tuning fork — the hand-held 128Hz tuning fork is pinched at its farthest point until the two distal fork components come together. When released they generate a (non-audible) vibration at which point the single end of the

tuning fork is gently applied to nominated anatomical areas on the sole of the foot, informing the practitioner if the person has the ability to feel vibration in those areas. A more sophisticated calibrated system is the bios/neurothesiometer, which is





Figure 5. Painful ulceration on the ball of the foot.

response to the application of deep pressure, the pain may be interpreted at a site remote from the site of application

- ▶ Interpretation of stimuli — the patient's underestimation of pain.

In some patients with neuropathy sharp stimuli is simply not felt, or the sensation is altered, with a dull ache being felt instead. In some cases the stimuli is registered in anatomical sites other than the area/s that are being stimulated.

It is important to assess for differential causes of disordered pain sensation in the foot as these may not be related to nerve dysfunction, but other pathological processes (*Table 3*).

### Neuropathy according to type of fibre

The complexities of neuropathy can be confusing to even the most experienced of healthcare workers. *Table 2* summarises the relationship between nerve fibre damage, the mode of assessment and the typical clinical presentation (Faris, 1991).

### Painful diabetic neuropathy

Painful neuropathy is an acute episode of unremitting pain (often affecting the leg and foot) with heightened sensitivity to touch. In some patients pain can be caused even by contact which can result in sleeplessness.

Painful neuropathy is a distressing condition and if symptoms progress over time, depression may follow with significant weight loss.

Painful neuropathy is notoriously difficult to manage and evidence from large trials recommends optimising glycaemic control as early as possible to control painful episodes (Diabetes Control and Complications Trial, 1993; UK Prospective Diabetes Study, 1998; Department of Health, 2001). Increased glycaemic levels significantly reduce normal nerve conduction capacity interfering on a number of pharmacological levels, therefore, despite many metabolic structural and functional theories, the commonly accepted

recommendation is to optimise glycaemic control to reduce the incidence of neuropathic changes.

While glycaemic control is being established, interim measures are needed to reduce the painful symptoms (Gordon, 2004). These include:

- ▶▶ Analgesics
- ▶▶ Antidepressants
- ▶▶ Anticonvulsants
- ▶▶ Antiepileptics.

Complementary therapies, such as acupuncture, have also demonstrated some success in the management of painful neuropathy (Smith, 2005).

### Case study

The foot pictured in *Figure 5* was affected by painless neuropathy. However, due to infection (detected on visual examination) there was discomfort in the foot. The infection was caused by a severe cellulitic response extending from the ulcer site along the border of the foot — this was later confirmed by swab results.

The discomfort was not felt as the severe pain that might be expected from significant ulceration, and the sensation was not felt directly at the site of trauma, but reported within the arch region of the foot. This might be explained by disordered pain receptors misinterpreting the pain message or receptors recognising pain as referring from the site due to extending infection. The infection was successfully managed by oral antibiotics and the patient advised to optimise glycaemic control.

## Conclusion

Peripheral neuropathy is a common complication of diabetes. Diabetic neuropathy commonly presents as painless neuropathy, whereby protective sensation is lost and the limb becomes numb. The consequences are recurrent episodes of foot ulceration with complications of infection and, if coupled with vascular changes, may result in amputation of digits or even loss of the limb.

However, painful diabetic neuropathy can also develop — this can be particularly debilitating and can result in symptoms such as heightened sensitivity to touch.

It is important that healthcare workers undertake regular neurological assessments and establish the type of neuropathy present. Management strategies can then be implemented and further deterioration avoided. **WE**

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## Key Points

- ▶▶ Neuropathy, or the impairment of nerve structures and function, is a common complication in diabetes.
- ▶▶ The most common manifestation is the loss of pain sensation in the peripheries, particularly the feet.
- ▶▶ The lack of pain results in the inability to detect trauma and can result in injury, ulceration, infection and even amputation.
- ▶▶ Assessment of the extent of diabetic neuropathy is essential to avoid the risk of damage.

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## Glossary

**Autonomic neuropathy:** damage to nerves responsible for autonomic function, such as smooth muscle in blood vessels.

**Charcot:** osseous structural changes most often in the foot with painless fracture or dislocation of the joints associated with nerve dysfunction and disorders of vascular perfusion to the osseous tissue.

**Glycaemic control:** control of blood pressure levels in people with diabetes.

**Ischaemic:** deficiency of blood to the tissues as a result of obstruction or constriction of blood flow.

**Monofilament:** a measurement tool for assessing protective pain sensation.

**Motor neuropathy:** damage to nerves generally supplying muscle tissue.

**Neuropathic ulcer:** a breach in the skin integrity associated with neurological damage.

**Neuropathy:** structural and/or functional damage to nerves.

**Neurotip:** a measurement tool for assessing the ability to discriminate between sharp and blunt.

**Painful neuropathy:** distressing abnormally heightened pain mostly in the peripheries associated with high blood pressure levels in people with diabetes.

**Peripheral vascular disease:** general disease of blood vessels in the periphery.

**Polyneuropathy:** disease of multiple peripheral nerves simultaneously.

**Sensory neuropathy:** damage to nerves generally supplying receptors for sense (i.e. touch/pain/pressure/warmth).

**Thermal perception:** ability to feel the sense of warm and cool.

**Vibration perception:** ability to feel the sense of vibration.

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