Assessment and management of patients with diabetic foot ulcers


**Abstract**

Diabetic neuropathy is a common complication of diabetes. Patients need to be informed of the effects of poorly managed diabetes and appropriate care to prevent diabetic neuropathy. This article provides a brief overview of the main complications associated with diabetes and discusses the different types of diabetic neuropathy. Risk factors in the development of diabetic foot ulcers are identified and the importance of timely assessment is recognised. Treatment and management of diabetic foot ulcers is discussed in relation to blood glucose control, infection, wound care, sleep and pain.

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**Aims and intended learning outcomes**

This article aims to highlight and discuss neuropathy as a long-term complication of diabetes. It provides information about the different types of neuropathy and the risk factors involved in the development of a diabetic foot ulcer. After reading this article and completing the time out activities you should be able to:

- Identify and define the different types of neuropathy that a person with diabetes may develop.
- Recognise the risk factors for neuropathy and the development of a diabetic foot ulcer.
- Consider the different elements and stages that should be included in a comprehensive foot examination of a person with diabetes.
- Discuss the principles of diabetic foot ulcer management and treatment, drawing on knowledge that is relevant, up to date and evidence-based.

**Introduction**

The prevalence of diabetes is increasing worldwide and is associated with high morbidity and mortality rates (Yokoyama et al 2007). At present, there are 2.9 million people in the UK diagnosed with diabetes and if trends continue, it is estimated that this figure will rise to 4.35 million in the next ten years (NHS Diabetes 2011). Approximately 15% of those with diabetes have type 1 diabetes and the remaining 85% have type 2 diabetes (Diabetes UK 2011).

Because of the autoimmune nature of type 1 diabetes, people who develop the condition can become acutely ill over a short period of time and are likely to require...
In contrast, type 2 diabetes is largely, but not exclusively, linked to obesity (Holt 2009). The development of type 2 diabetes and its related signs and symptoms are often subtle and dismissed by the person experiencing them as being caused by other factors. These include feeling tired because the person is getting older or has a busy lifestyle, drinking more as the weather is warmer, and passing more urine because he or she is drinking more. As a result, a person can have type 2 diabetes for up to 12 years before he or she seeks medical help and a diagnosis is made. Consequently, 50% of people with type 2 diabetes may have already developed one or more complications of the condition at the time of diagnosis (Holt 2009).

Complications of diabetes, which are many and varied, affect the large blood vessels, resulting in cardiovascular disease, stroke and peripheral vascular disease. Diabetes also affects the microvascular systems of the body, causing retinopathy, nephropathy and neuropathy. Diabetic neuropathy is the most common long-term complication of type 2 diabetes (Boulton 1998). Peripheral neuropathy and vascular disease, the main contributors to foot disease, are found in more than 10% of people when they are diagnosed with diabetes (Boulton et al 2005a). In addition, the first year following diagnosis is a crucial period for the development of foot ulcers and amputations (Boulton et al 2005a). People with diabetes have a 30-50% risk of developing chronic peripheral neuropathy, with 10-20% of those diagnosed with neuropathy going on to develop severe neuropathic symptoms (Marshall and Flyvbjerg 2006).

**Diabetic neuropathies**

Neuropathy is defined as nerve damage and is a common and serious complication of diabetes (Brem et al 2006). Damage to any nerve fibre is usually insidious and often goes unnoticed. If left untreated, damage to the nerve fibres will result in the development of an assortment of clinical signs and symptoms (Urbancic-Rovan 2005). Neuropathy is associated with cardiovascular disease and is therefore a marker of individuals who are at an increased risk of mortality (Bloomgarden 2007).

**Motor neuropathy**

Mainly found in older people with type 2 diabetes, motor neuropathy occurs when there is damage to the nerves supplying the muscles of the body, resulting in muscle atrophy and weakness (Boulton et al 2005b). When the nerves supplying the muscles in the foot are damaged, these muscles are unable to maintain the person’s healthy foot shape and the foot becomes deformed. This deformity leads to an alteration in the biomechanics of walking, and foot pressure points during standing and walking. Calluses form in abundance on the new, alien pressure points and sub-metatarsal head fat pads become thin. This increases the force of plantar pressure that ultimately results in the formation of a foot ulcer, which has a high risk of becoming infected (Urbancic-Rovan 2005).

**Sensory neuropathy**

The most common presentation of neuropathy in those with diabetes is sensory neuropathy, which affects up to 50% of patients (Boulton et al 2005b). It generally starts in the toes and over time may affect other areas such as the legs and hands (Bloomgarden 2007). It results when the sensory nerves become damaged and distorted messages are received by the brain relating to pain, pressure and temperature. This leads to decline of the normal sensations experienced by a person (Brem et al 2006). As the person is unable to feel the development of a lesion or an episode of trauma, he or she is unlikely to take the required evasive action and a foot ulcer may develop. The person may be unaware of this, especially if it is on the sole of the foot and cannot readily be seen (Figure 1).

Because of the damaged nerve pathways, patients may complain of pain (Bloomgarden 2007) and a burning sensation in their lower limbs and feet, or they may feel like they are walking on hot coals or cotton wool. They can...
experience a deep aching pain in their legs, which is typically much worse at night. Other patients may be completely asymptomatic (Boulton et al 2005b).

**Autonomic neuropathy**
A common condition in people with diabetes is autonomic neuropathy, which arises from damage to the sympathetic and parasympathetic nerves. It can affect several different systems in the body, resulting in high levels of morbidity and mortality. The clinical signs and symptoms of autonomic neuropathy can be diverse and varied, but tend to be linked mainly to disturbances of the cardiovascular system, digestive system and genitourinary system (Holt 2009).

**Charcot neuropathy**
An uncommon condition, charcot neuropathy is an acute disease process that destroys the bones of the foot, leading to profound foot deformity (Figure 2). It is caused by increased blood flow to the feet, which ‘washes away’ the essential bone minerals leading to thinning of the foot bones. Charcot neuropathy is typically seen in patients with long-standing type 1 diabetes and is associated with poor diabetes control (Levy 2006). It can occur in those with type 2 diabetes, but this is less typical. Charcot neuropathy usually occurs as an acute phase following minor injury to the foot that may have gone unnoticed for some time, probably as a result of the additional presence of sensory neuropathy (Holt 2009).

Approximately 30% of patients complain of pain, but often X-rays of the foot at the time are surprisingly unremarkable and a bone scan would be required to determine the extent of any bone destruction (Holt 2009). If left untreated, the shape of the foot will begin to change irreversibly within just a few weeks and the person may begin to experience a ‘crunching’ sound when walking. The foot takes on a characteristic ‘rocker bottom’ appearance – where the natural arch of the foot drops and the shape of the foot resembles the bottom of a rocking chair – which causes pressure ulcers to develop on the plantar aspects. There will be evidence of new bone formation and partial or complete dislocation of the joints (Holt 2009).

**Risk factors**
A diabetic foot ulcer is defined as any skin breakdown on the foot of a person with diabetes, including minor eruptions on the toes, heel, and the dorsal and plantar foot (Brem et al 2006). Foot lesions and ulcers do not erupt spontaneously and are usually the result of some kind of trauma coupled with neuropathy and accompanying infection (Brem et al 2006).

Common causes of trauma include ill-fitting footwear. The person may have bought a new pair of shoes, boots or trainers that have led to the development of a blister on the foot. Because of the presence of sensory neuropathy, the person is unable to feel the normal pain from the blister and continues to wear the footwear. This may lead to increased trauma and development of an open wound, which provides a portal of entry for systemic infection (Holt 2009). This trauma process can also occur if the person walks barefoot and steps on something sharp or acquires a foreign object such as a stone in his or her shoe, which would ordinarily be well fitting. This can be particularly problematic when on holiday because people tend to walk barefoot on the beach and around swimming pools, which are high-risk areas for foreign objects and infection. Ill-fitting hosiery can also be a cause of foot ulcers, for example, from something as simple as a prominent seam in a pair of socks.

Callus formation on the plantar surface of the foot has been shown to result in a
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77-fold increase in ulceration at the callus site if there is concurrent peripheral insensitivity (Murray et al 1996). In addition, the use of improper instruments for self-foot care and the application of corn, hard-skin and verruca cures can lead to healthy tissue becoming damaged and subsequently infected. Unwittingly putting feet and legs into very hot water can cause scalds without the person being aware, and sitting too close to fires can burn the skin, which may also occur if the person does not take sensible precautions to avoid sunburn.

The Diabetes Control and Complications Trial Research Group (DCCT) (1995), which studied people with type 1 diabetes, and the UK Prospective Diabetes Study Group (UKPDS) (1998), which studied those with type 2 diabetes, both confirmed that uncontrolled diabetes and hyperglycaemia were significant contributing factors to the development and progression of neuropathy. The DCCT (1995) reported that nerve damage could be reduced by up to 60% in people with type 1 diabetes who had optimal blood glucose control.

In addition, the UKPDS (1998) found that patients in the study who were randomised to the intensive blood glucose control group had a significantly lower incidence of neuropathy after both nine and 15 years.

Patients are also at high risk of developing diabetic foot ulcers if they have a history of foot ulceration or have other long-term microvascular complications of diabetes, such as retinopathy and nephropathy (Boulton et al 2007). These complications occur mainly in people who have had diabetes for a long period and their overall blood glucose control has been poor (Yokoyama et al 2007). The presence of retinopathy and/or nephropathy indicates that there is damage to the microvascular system, making it highly unlikely that the nervous system will have escaped the same harm (Yokoyama et al 2007).

Assessment

Diabetic foot ulcers are the single greatest cause of non-traumatic limb amputation in people with diabetes: amputations are 15 times more common in those with diabetes than those without the disease (Brem et al 2006). Amputation carries a higher mortality rate than colon, breast or prostate cancer, and up to 80% of people with diabetes will die within five years of having an amputation (Diabetes UK 2012a). More significantly, Khanolkar et al (2008) reported that only 50% of all diabetes-related amputees will survive for two years following surgery.

It is estimated that between £639 million and £662 million is spent each year on foot ulcers and amputations in England (NHS Diabetes 2012), but added to the financial cost to the NHS is the cost to the individual. Amputations and foot ulcers affect individuals’ quality of life in terms of pain, poor mobility affecting many aspects of daily living, low self-esteem and depression, relationship difficulties and breakdown, and the person’s ability to work, which for many will have significant financial consequences.

Timely and comprehensive assessment of the patient is vital as there is evidence to suggest that rapid access to multidisciplinary foot care teams can result in accelerated healing, reduction in amputations and higher survival rates (NHS Diabetes 2012). Ideally, in each locality there should be staff specifically trained in foot protection and care, and facilities to refer a person with an ulcer to specialist care within 24 hours of diagnosis.

Complete time out activity

Guidelines published by the National Institute for Clinical Excellence (NICE) (2004a, 2004b) require that all people with diabetes should have an annual foot examination. As a minimum, this should include:

- Testing of foot sensation using a 10g monofilament or vibration test. Without the patient looking, pressure from a monofilament or vibration fork is applied to at least five different areas on the sole of the foot. Decreased sensation at any of the sites tested could be an indication of neuropathy.
- Palpation of foot pulses.
- Inspection of any foot deformity and footwear. Based on the findings of the foot examination, the person would then be classified as low risk, increased risk, high risk or ulcerated foot. Despite the existence of the NICE (2004a, 2004b) guidelines and the fact that identifying the at-risk foot does not require any expensive equipment, the National Diabetes Audit (2012) found that more than one third (33.4%) of people with type 1 diabetes aged 55 and younger did not receive an annual foot check by a healthcare professional. A total of 84.5% of people with type 1 diabetes aged over 55 and 86.2% of people with type 2 diabetes were more likely to have a foot examination each year, however these figures still fall short of the 90-100% target ideally required (National Diabetes Audit 2012).

Complete time out activity
The information given in the National Diabetes Audit (2012) is limited and not broken down into each component of the NICE (2011) guidance. Therefore it is possible that only some elements of the foot examination are carried out, yet are recorded as being completed. In view of this, Diabetes UK (2012b) issued a checklist of 15 Healthcare Essentials that informs people with diabetes what care they should expect. It highlights the need for the skin, circulation and nerve supply of the feet to be checked annually by a GP, but it does not go on to advise patients that this has to be conducted on a bare foot and should not be done through socks or stockings, or by asking the person if there are any problems.

Complete time out activity 4

**Treatment and management**

Diabetic foot ulcers are classified as chronic wounds that will not heal on their own and require active treatment. Several factors have been identified in the treatment and management of diabetic foot ulcers.

**Blood glucose control**

Both the DCCT (1995) and UKPDS (1998) suggest that optimal blood glucose control helps to prevent the occurrence and development of diabetic neuropathy. Therefore, the first step in the management of patients with diabetic neuropathy should be to achieve good blood glucose control within a minimal period of time.

The International Diabetes Federation (IDF) (2007) posed the question of what should be considered optimal blood glucose levels. Based on a comprehensive systematic review, they concluded that while blood glucose levels should be individualised to the patient, each person should aim for a capillary blood glucose level less than or equal to 5.5mmol/L pre-prandial and no higher than 7.8mmol/L two hours after a main meal. Their overall HbA1c should be less than 48mmol/mol. Healthcare professionals and patients need to take seriously the implications of high blood glucose levels to reduce the incidence of amputations (Figure 3).

Complete time out activity 5

**Infection**

Foot ulceration provides an entry point for pathogens, leading to the development of infection (Figure 4). If an infection is left untreated it can threaten the viability of the limb and also the person’s life. Infection can occur in the soft tissue and/or surrounding bone and it can track up the leg and become systemic (Kravitz et al 2007). In addition, the usual clinical signs of infection can often be masked by the presence of neuropathy; therefore careful assessment is crucial and treatment should be commenced if in doubt.

Immediate hospitalisation and aggressive treatment is often required if there is purulent drainage, significant necrotic tissue, exposure of bone and/or pyrexia with leukocytosis (Kravitz et al 2007). Tissue specimens and/or wound swabs should be sent to the laboratory for wound culture and a plain X-ray of the foot can help to identify the presence of foreign bodies, gas in the tissues or evidence of osteomyelitis (Cavanagh et al 2005), all of which are serious complications of diabetic foot ulcers.

Antibiotics are usually required. The choice of antibiotic will be based initially on the probable causative organisms and will then be modified on the clinical response and results of the wound culture. In severe cases of infection, intravenous antibiotics will need to be given at least initially. Any renal or hepatic dysfunction or patient allergy will also need to be considered before treatment is commenced (Cavanagh et al 2005).
**Wound care**

Another key objective in the management of a neuropathic ulcer is to achieve and maintain a moist wound environment (Kravitz et al 2007). While there are several different types of wound dressings and applications available, there does not appear to be one remedy for all foot ulcers, therefore each patient and each foot ulcer will need to be treated on an individual basis. General principles are that the selected wound dressing should protect the ulcerated area from trauma and contamination, absorb exudate, keep the wound warm, allow oxygen to enter and not cause trauma to the site during removal (Kravitz et al 2007).

Usual clinical management will also include regular surgical debridement to remove the necrotic wound bed as well as any callus formation, which may alter gait and pressure points. It is also thought that appropriate debridement can correct any wound healing abnormalities and re-set the normal healing process (Falanga 2005).

Relieving the pressure on ulcers is commonly referred to as off-loading and is crucial in the healing of foot ulcers. Patients also need to be informed that they should never walk in the same shoes or wear the same hosiery that has contributed to the foot ulcer (Cavanagh et al 2005).

Off-loading can be achieved using several different mechanisms, including specially designed padded slippers and shoes, removable orthoses and below-knee irremovable casts. It is crucial that any off-loading mechanism does not cause further damage, and that all irremovable casts need to be properly applied and changed weekly. The cast would need to be worn until healing has occurred, which is typically around six weeks (Cavanagh et al 2005). Crutches, bed rest and wheelchair use are not as effective because of poor patient compliance and the limb not being properly rested and weight-free (Cavanagh et al 2005).

**Sleep**

Any condition that causes chronic pain can lead to sleep problems, and up to 30% of patients can experience painful diabetic peripheral neuropathy (Bloomgarden 2007). Frequently, this group of patients experiences nocturnal exacerbations of neuropathic pain and an abnormal increase in sensitivity. Allodynia is common, where even light contact with the bedclothes can cause the sensation of severe pain leading to disturbed sleep (Zelman et al 2006).

Research shows that less than six hours’ sleep per night alters insulin and glucose levels and decreases insulin sensitivity (Zelman et al 2006), which can predispose the individual to poor diabetes control and exacerbate neuropathy. Poor sleep patterns have also been associated with increased hunger for high carbohydrate foods (Spiegel et al 2004), which can also have deleterious effects for the person with diabetes, especially in relation to weight gain, increased insulin resistance and sub-optimal blood glucose control (Spiegel et al 2004).

Routine screening for sleep disturbances should to be carried out on all patients with neuropathy, and treatment should include the best possible pain management. Referral to sleep specialists may be required for those with persistent sleep problems.

**Pain**

Neuropathic pain is defined as pain in the limbs that is not caused by trauma or any other external influence (Yokoyama et al 2007). It is particularly difficult to control and many different agents have been tried. Tricyclic antidepressants, such as amitriptyline hydrochloride, have been found to be particularly effective in relieving nerve pain and are often prescribed as a first-line treatment. However, these drugs are associated with a number of uncomfortable side effects, including dry mouth, constipation, lethargy and drowsiness, which means they are not well tolerated by patients. They are also known to cause more serious complications such as arrhythmia, myocardial infarction and glaucoma, and need to be prescribed and administered with caution (Berger et al 2007).

The anticonvulsant gabapentin is now commonly prescribed for neuropathic pain and has been proven to be efficacious. It is also associated with side effects such as dry mouth, diarrhoea, hypertension and changes to appetite, but these can be minimised if a small dose (such as 300mg) is prescribed initially and gradually titrated upwards. Most patients will require at least 1.8g/day for relief of symptoms (Boulton et al 2005b).

Pregabalin also provides pain relief for neuropathic pain, with the effects starting after one week and persisting to 12 weeks and beyond (Bloomgarden 2007). It is given twice per day and may be favoured over gabapentin, which needs to be given in three daily doses, as it can encourage patient compliance and concordance. In cases of
severe pain, an antidepressant and an anticonvulsant can be used together or combined with a topical or non-pharmacological treatment (Boulton et al 2005b).

**Conclusion**

Diabetic neuropathy is a serious and debilitating long-term complication of diabetes. Many people fail to recognise the early warning signs and symptoms, resulting in unnecessary delays in seeking medical help. Prevention is crucial and can be largely achieved with optimal blood glucose control, knowledge of the risk factors for the development of diabetic foot ulcers and annual foot inspections by a trained healthcare professional.

Immediate action is required for the person who develops a foot ulcer to ensure the healing process is not delayed. Referral strategies should be in place and all healthcare professionals need to be familiar with them. Wound care and management should be prescribed on an individual patient basis to promote adherence with treatment. The ultimate aim is to avoid infection and promote rapid healing, thereby reducing the risk of serious complications, such as amputation, and preventing the recurrence of further foot ulcers. **NS Complete time out activity**

**References**


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