Preventing foot complications in people with diabetes mellitus

Dan Howarth

Abstract

‘Diabetic foot’ is a term used to describe a group of syndromes in which neuropathy and/or ischaemia lead to tissue breakdown and reduced resistance to infection in a patient with diabetes mellitus. Foot ulceration is a serious and potentially limb-threatening complication of diabetes that can lead to pain, tissue necrosis and amputation, and may significantly affect an individual’s well-being and mobility. Foot complications also have wider economic implications for healthcare services. Therefore, it is important to reduce the risk of foot complications through regular foot assessments and providing patient education and appropriate referral to specialist services. This article discusses foot complications in people with diabetes, outlining the causes, signs and symptoms, and associated risk factors. It also outlines the assessment and prevention measures that patients and healthcare practitioners can take to reduce the risk of foot complications.

Author details

Dan Howarth, head of care, Diabetes UK, London, England

Keywords

blood glucose, diabetes mellitus, diabetic foot ulcers, glycaemic control, type 1 diabetes, type 2 diabetes
Diabetes can cause a variety of acute, chronic, focal, and diffuse neuropathy syndromes, the most common of which is diabetic peripheral neuropathy (Jarrett 2013). Diabetic peripheral neuropathy is characterised by degeneration of, or damage to, the peripheral nerves, resulting in a loss of sensation and autonomic dysfunction (Jarrett 2013). The nerve damage that occurs through diabetic peripheral neuropathy is a common complication of both type 1 and type 2 diabetes (Schreiber et al 2015).

Patients with diabetic peripheral neuropathy can describe a range of sensory symptoms. These include a loss of pain sensation in the feet, tingling, the feeling of ‘pins and needles’, burning, a sensation of ‘electric shocks’, allodynia (pain associated with stimuli that usually do not cause pain, such as light touch) and hyperalgesia (increased sensitivity to pain) (Schreiber et al 2015, Juster-Switlyk and Gordon Smith 2016). Juster-Switlyk and Gordon Smith (2016) suggested that often patients with the most severe painful symptoms have minimal or no sensory deficit on examination or electrodagnostic (nerve electrical conduction) studies. They identified that neuropathic pain affects up to 20-30% of patients with diabetic peripheral neuropathy, and is one of the main reasons that these patients seek healthcare (Juster-Switlyk and Gordon Smith 2016).

The effects of diabetic peripheral neuropathy are progressive, permanent and varied. There are three main types of diabetic peripheral neuropathy – sensory, motor and autonomic (Jarrett 2013) – which are outlined in Box 1.

Diabetic peripheral neuropathy usually occurs as a result of hyperglycaemia and microangiopathy, also known as microvascular or small vessel disease (Iqbal et al 2018). Effective glycaemic control through medicines optimisation and lifestyle changes such as healthy eating, physical activity and smoking cessation has been shown to prevent or delay the progression of peripheral neuropathy in patients with type 1 diabetes (Ang et al 2014, Iqbal et al 2018). However, in type 2 diabetes, there is limited evidence that improved glycaemic control slows the progression of peripheral neuropathy (Iqbal et al 2018).

Without regular foot assessments the patient may be unaware of the occurrence of any damage, for example caused by the rubbing of ill-fitting footwear or a stone in the shoe, because of the loss of sensation. This may lead to infection, ulceration and delayed healing because of peripheral vascular disease, potentially resulting in necrosis, morbidity and amputation of the affected area (Alexiadou and Doupis 2012).

**Diabetic foot**

Diabetic peripheral neuropathy is a significant risk factor for foot complications associated with diabetes, commonly known as ‘diabetic foot’ (Feng et al 2009). This term is used to describe a group of syndromes in which neuropathy and ischaemia lead to tissue breakdown and reduced resistance to infection (Jarrett 2013). The signs and symptoms of diabetic foot include clawed toes, calluses, bounding foot pulses, ulceration, numbness and Charcot foot (Jarrett 2013).

Charcot foot is a serious complication of diabetic peripheral neuropathy (Rogers et al 2011). It is an inflammatory syndrome and is characterised by bone and joint disorganisation, secondary to factors such as underlying

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**Box 1. Types of diabetic peripheral neuropathy**

**Sensory neuropathy**

Sensory neuropathy is the most common form of diabetic peripheral neuropathy and is associated with the formation of foot ulcers. It involves a loss of protective sensation, such as the ability to feel pain, pressure and temperature. Sensory neuropathy is progressive and the patient may be unaware it is developing, so their feet are at risk of damage. Therefore, daily foot examinations and regular reviews are essential to identify this condition.

**Motor neuropathy**

Motor neuropathy contributes to structural changes in the foot, such as the development of a high-arched foot, clawing of the toes and prominent metatarsal heads. Displacement or loss of the fat pads under the metatarsal heads can also occur, which may lead to areas of high foot pressure and callus formation.

**Autonomic neuropathy**

Autonomic neuropathy involves damage to the nerves that control involuntary functions, such as vascular tone and sweating. In the foot, this can result in derangement of the sweat glands, resulting in dry and non-sweating skin. Arterial vasoconstriction and dilatation may also be impaired, which can lead to blood flowing into the venous system, resulting in distended veins on the dorsum of the foot.

(Adapted from Jarrett 2013)
Diabetes can cause a variety of acute, chronic, and peripheral foot complications. Foot care must be included in the overall management of diabetes mellitus. There are several reasons why people with diabetes may experience foot complications, including suboptimal glycaemic control, hypertension, smoking and increased duration of diabetes. Diabetes can cause a variety of acute, chronic, focal, and diffuse neuropathy syndromes, the most common of which is diabetic peripheral neuropathy. Foot care must be included in the overall management plan for the patient's diabetes, particularly effective glycaemic control and the reduction of risk factors. The healthcare practitioner can assist the patient to reduce risk factors by supporting smoking cessation, ensuring the patient’s blood pressure is within the target range, and monitoring and managing their cholesterol levels. In addition to assessing the feet for the presence of diabetic peripheral neuropathy and peripheral vascular disease, the healthcare practitioner should discuss the overall management of diabetes with the patient.

**Key points**

- Diabetes mellitus is associated with a series of macrovascular and microvascular changes that can manifest as a wide range of complications.
- There are several reasons why people with diabetes may experience foot complications, including suboptimal glycaemic control, hypertension, smoking and increased duration of diabetes.
- Diabetes can cause a variety of acute, chronic, focal, and diffuse neuropathy syndromes, the most common of which is diabetic peripheral neuropathy.
- Foot care must be included in the overall management plan for the patient's diabetes, particularly effective glycaemic control and the reduction of risk factors. The healthcare practitioner can assist the patient to reduce risk factors by supporting smoking cessation, ensuring the patient’s blood pressure is within the target range, and monitoring and managing their cholesterol levels.
- In addition to assessing the feet for the presence of diabetic peripheral neuropathy and peripheral vascular disease, the healthcare practitioner should discuss the overall management of diabetes with the patient.

Peripheral vascular disease

Peripheral vascular disease most commonly occurs as a result of atherosclerosis, in which a build-up of atherosclerotic plaque causes arterial stenosis (narrowing) or occlusion. This tends to affect the blood vessels leading to the hands and feet, resulting in a reduction in blood flow to the affected limb or limbs (Morley et al 2018). Diabetes is a significant risk factor for peripheral vascular disease. Signs of peripheral vascular disease include changes in skin colour, such as new mottling or skin discolouration, and changes in temperature, since a cool or cold foot may indicate ischaemia. Other signs include: the presence of intermittent claudication (cramping pain in the leg induced by exercise); ischaemic pain in the leg on walking or exercise; and any pain when the leg is at rest, which will indicate increasingly critical ischaemia.

The ankle brachial pressure index (ABPI) test can be used to assess the arterial circulation in the lower leg for those with a notable lack of protective sensation, who are therefore at high risk of foot complications (Mishra et al 2017). The ABPI test involves calculating the ratio of the blood pressure at the ankle compared with the blood pressure at the upper arm. A lower blood pressure at the ankle compared with the arm produces a lower ratio that indicates a reduction of arterial blood flow to the lower limbs. However, it is important to note that people with diabetes and peripheral arterial disease may have a normal or raised ABPI because of hardening of the arteries (National Institute for Health and Care Excellence (NICE) 2018). Another issue is that the accurate measurement of ABPI is dependent on the competence of the healthcare practitioner (Mishra et al 2017). Therefore, a diagnosis of peripheral arterial disease in people with diabetes should not be excluded based on a normal or raised ABPI alone.

**Foot care in people with diabetes**

Mishra et al (2017) asserted that foot complications can be prevented through effective glycaemic control (maintaining blood glucose levels), regular foot assessment, appropriate footwear, patient education and early referral to specialist services for pre-ulcerative foot lesions. Jarrett (2013) suggested that a multidisciplinary team approach, including appropriate risk assessment, referral management and interventions, can reduce the number of foot and leg amputations resulting from diabetic peripheral neuropathy.

Box 2 outlines the risk factors for foot complications associated with diabetes mellitus.

Empowering patients with diabetes to be involved in shared decision-making and to become a proactive partner in their foot care is essential to reduce complications associated with diabetes. When meeting a patient, it is often beneficial for the healthcare practitioner to begin by assessing the patient’s understanding of their condition and foot complications. This may include asking the patient what they understand to be the
Box 2. Risks factors for foot complications associated with diabetes mellitus

- Peripheral and autonomic neuropathy
- Peripheral vascular disease
- Previous foot ulceration
- Microvascular complications, such as retinopathy and end-stage renal disease
- Increased duration of diabetes
- Elevated HbA1c (glycated haemoglobin) – more than 48mmol/mol (6.5%)
- Cigarette smoking
- Hypertension
- Dyslipidaemia (changes in the concentrations of lipids in the blood)

Box 3. Undertaking a daily foot examination

- Ensure that all of each foot is exposed. Examine the two feet together to enable a comparison
- Wash your hands and feel both feet together from the toes to the ankle. The foot will feel warmer at the ankle and cooler towards the toes. The temperature should not be overly cold or hot, and should be the same in each foot. An overly cold foot may indicate ischaemia, while an overly hot foot may indicate inflammation
- Examine the feet visually for signs of new skin blemishes, such as scars, scabs, hard skin or calluses
- Inspect the toes and the areas in between them for changes in skin colour and dry or flaky skin
- Inspect the toenails to ensure they are not pushing or digging into the skin. It is possible that the patient may not experience any discomfort or pain as a result of diabetic peripheral neuropathy. The toenails should be cut carefully and straight across
- If any signs of a potential foot complication are identified, contact specialist services, for example the diabetes specialist nurse or team

Foot care must be included in the overall management plan for the patient’s diabetes, particularly effective glycaemic control and the reduction of risk factors. The healthcare practitioner can assist the patient to reduce risk factors by supporting smoking cessation, ensuring the patient’s blood pressure is within the target range, and monitoring and managing their cholesterol levels. Regarding blood pressure management, it is important for the healthcare practitioner to check the desired target range, because these targets are often set slightly lower in clinical guidelines for patients with diabetes. It is also important to consider broader risk factors for foot ulceration, such as visual impairment or living alone (Jarrett 2013), which could affect an individual’s ability to undertake daily foot examinations and manage their diabetes effectively.

In addition to modifying metabolic factors such as suboptimal glycaemic control, effective interventions to prevent foot ulceration include educating patients about the benefits of prescription footwear, regular foot examinations, and intensive podiatric care (Juster-Switaly and Gordon Smith 2016). Educating patients with diabetes about the prevention of foot ulcers is an essential aspect of nursing care; however, Nather et al (2018) reviewed six patient education programmes and concluded that further research is required to determine the effectiveness of the various teaching methodologies used. Furthermore, Dorresteijn and Valk (2012) found there is insufficient evidence that limited patient education alone is effective in reducing the incidence of foot ulcers and amputation. However, this should be interpreted as a lack of evidence rather than evidence of no effect. Therefore, it is important for all healthcare practitioners caring for patients with diabetes to be aware of the latest evidence regarding effective education interventions.

Daily foot examination

A daily foot examination should be incorporated into the patient’s everyday activities, to ensure that it becomes a routine task that is not easily forgotten. A foot examination is a practical activity, so it is often valuable for the healthcare practitioner to ask the patient to demonstrate their foot examination technique and to offer encouragement and support in optimising its effectiveness. It is also important to ask the patient what they consider to be the signs of potential foot complications, and whether they know who to contact – for example the diabetes specialist nurse or team – if they identify any of these signs during an examination. Box 3 outlines the steps involved in a daily foot examination, while Box 4 explains the advice and education that healthcare practitioners can provide to patients undertaking these examinations.

Annual foot review

All patients with diabetes should be offered an annual foot review with a competent healthcare practitioner in primary or secondary care settings. Foot reviews may be undertaken more frequently based on the individual’s needs, for example their ability to undertake self-care activities such as daily foot examinations and manage their diabetes effectively, or if they are at increased risk of developing foot complications. The review process should involve a physical examination of the feet and discussion with the patient, to cover the following three main areas:

- Assessing the feet.
- Monitoring any concerns.
- Working in partnership with the patient to provide advice and education on foot care and to assess their ability to undertake self-care activities.

During the annual foot review, the healthcare practitioner should assess the pulses in the feet – the dorsalis pedis or posterior tibial arteries – for blood flow. A Doppler device may be used to assess the blood flow audibly if these pulses are challenging to locate.

In addition to assessing the feet for the presence of diabetic peripheral neuropathy and peripheral vascular disease, the healthcare practitioner should discuss the overall management of diabetes with the patient. This should include exploring risk factor management, for example smoking cessation, and liaising...
Box 4. Patient advice and education for undertaking a daily foot examination

Healthcare practitioners should advise patients who are examining their own feet to:

- Incorporate a foot examination into their daily routines, for example by undertaking this when they are putting on or taking off their socks and shoes.
- Purchase a small handheld mirror, which they can place on the floor during daily foot examinations to ensure they inspect all areas of the foot.
- Wear footwear that is comfortable and ensure that their shoes do not rub against any areas of their feet.
- When putting on or taking off their shoes, tip them up to ensure no foreign objects are hidden inside, such as a stone, which could damage their foot.
- Avoid walking barefoot, particularly on grass, gravel or sand.
- Protect the feet from sunburn by using sunscreen with a high sun protection factor and/or covering the feet in strong sunlight.
- Avoid using corn-removing plasters or blades.
- Wash their feet carefully each day, drying them with a soft towel, particularly between the toes where infections may occur, such as athlete’s foot (tinea pedis).
- Moisturise their feet if they are dry.
- Access their local podiatry service for expert foot care if required.

(Adapted from Diabetes UK 2016)

Box 5. Monofilament testing procedure

Monofilament testing must be undertaken by an appropriately trained healthcare practitioner.

1. Explain the procedure to the patient and wash your hands.
2. Ask the patient to sit or lie comfortably, with both legs stretched out and the soles of their feet exposed.
3. Test the monofilament on another site, such as the upper arm, so that the patient knows what the procedure involves and the sensation to respond to.
4. Ask the patient to close their eyes and answer ‘yes’ each time they feel the soles of their feet being touched.
5. Hold the monofilament at a 90-degree angle to the skin and press until it buckles to 1cm. Hold it there for 1-2 seconds before removing it, pausing between each application of the monofilament.
6. Test different sites in a random sequence to prevent the patient guessing where the next area will be. Boulton et al (2008) recommended testing four sites – the first, third and fifth metatarsal heads and the plantar surface (sole) of the distal hallux (big toe) (Figure 2a, 2b) – but ensure that you follow your local healthcare organisation guidelines.
7. Avoid any callused areas.
8. If a patient fails to respond to a site being touched, test the site again twice in a random sequence. If they fail to respond to the site being touched all three times, record a loss of protective sensation. Loss of protective sensation at even a single site indicates that the patient is at risk of foot complications.

(Boulton et al 2008, Mishra et al 2017)

Figure 2. Monofilament testing sites and procedure

a) b)

- First metatarsal
- Third metatarsal
- Fifth metatarsal

Assessing for diabetic peripheral neuropathy

At the annual foot review, the healthcare practitioner should touch various areas of the patient’s feet in a random sequence to assess for loss of protective sensation, which will indicate diabetic peripheral neuropathy. A common method of undertaking this is via monofilament (Semmes-Weinstein)
testing (Dros et al 2009, NICE 2016, SIGN 2017). Monofilament testing is an inexpensive, easy-to-use and portable test (Dros et al 2009); however, some research has questioned the sensitivity of the test in detecting diabetic peripheral neuropathy (Dros et al 2009, Mishra et al 2017, Wang et al 2017). The use of a 10g monofilament is generally recommended (Mishra et al 2017), although similar validated tools can also be used. During the test, the monofilament exerts a 10g buckling force when it bends; an inability to sense this 10g pressure is the consensus definition for loss of protective sensation (Mishra et al 2017). Box 5 outlines the monofilament testing procedure.

**Conclusion**

Diabetic foot is a serious complication of diabetes that can affect the integrity of the foot, and can significantly affect the patient’s daily life and well-being. It can also have substantial economic implications for healthcare services.

Therefore, there is a need for a multidisciplinary team approach to monitoring the foot health of people with diabetes and proactively addressing any risk factors for foot complications. Healthcare practitioners must involve the patient as a proactive partner in their foot care and foot examinations, as well as providing advice, education and support. The use of standardised, validated tools and electronic patient records is essential to enable all members of the healthcare team to understand the plan of care.

**References**


