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.

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Preventing foot complications in people with diabetes mellitus

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Diabetes mellitus is a group of diseases characterised by high levels of blood glucose, which result from defects in insulin production and/or insulin action (Addie-Gentle et al 2007, Smyth 2018). There are 4.6 million people living with diabetes in the UK, and the number of people diagnosed with this condition more than doubled between 1998 and 2018 (Diabetes UK 2018).

There are various types of diabetes, although type 1 and type 2 diabetes are the most common. Type 1 diabetes is an autoimmune disease associated with genetic and environmental factors, such as viral disease and diet, that lead to the development of diabetes (Smyth 2018). In type 1 diabetes, the destruction of insulin-secreting beta cells occurs, and the pancreas subsequently produces little or no insulin (World Health Organization (WHO) 2006, Addie-Gentle et al 2007, Rees et al 2017). Smyth (2018) noted that individuals are generally younger when diagnosed with type 1 diabetes, and symptoms occur over a matter of weeks. In contrast, type 2 diabetes is characterised by a defect in insulin resistance and/or beta cell dysfunction, leading to a lack of insulin (Rees et al 2017, Smyth 2018). Type 2 diabetes is significantly more common than type 1 diabetes; approximately 90% of people with diabetes have type 2 diabetes, 8% have type 1 diabetes, and the remaining 2% have other types of diabetes (Diabetes UK 2019). Type 2 diabetes is usually diagnosed in people aged over 40 years; however, Lascar et al (2018) reported that there has been a significant increase in the prevalence of type 2 diabetes in adolescents and young adults. The main predisposing risk factors for type 2 diabetes are obesity; family history and a sedentary lifestyle (Wu et al 2014).

Diabetes is associated with a series of macrovascular and microvascular changes that can manifest as a wide range of complications (Bowling et al 2015). Microvascular complications affect the small blood vessels, and include: retinopathy (damage to the retina of the eyes), which can lead to blindness; nephropathy (kidney disease), which can lead to renal failure; and neuropathy (nerve damage), which can lead
to complications such as impotence and foot complications in people with diabetes (WHO 2019). Macrovascular complications affect the larger blood vessels, and include cardiovascular diseases such as myocardial infarction, stroke and peripheral vascular disease (WHO 2019).

Foot complications are considered to be a serious consequence of diabetes, and are associated with significant medical and economic implications (Al-Rubeaan et al 2015). Several longitudinal epidemiological studies have demonstrated that among patients with diabetes, the lifetime risk of developing a foot ulcer is around 25%, thereby accounting for two thirds of all non-traumatic amputations (Al-Rubeaan et al 2015).

**Foot complications associated with diabetes mellitus**

There are several reasons why people with diabetes may experience foot complications, including suboptimal glycemic control, hypertension, smoking and increased duration of diabetes. Without regular assessment and treatment, foot complications can have a significant effect on an individual’s health and well-being, and can lead to toe, foot, below-knee and above-knee amputation.

Diabetic peripheral neuropathy and peripheral vascular (arterial) disease are the two main causes of foot complications that can occur in people with diabetes (Cheer et al 2009, Fletcher 2019).

**Diabetic peripheral neuropathy**

Diabetes can cause a variety of acute, chronic, focal, and diffuse neuropathy syndromes, the most common of which is diabetic peripheral neuropathy (Juster-Switlyk and Gordon Smith 2016). 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.

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

<table>
<thead>
<tr>
<th>Sensory neuropathy</th>
<th>Motor neuropathy</th>
<th>Autonomic neuropathy</th>
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<td>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.</td>
<td>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.</td>
<td>Autonomic neuropathy involves damage to the nerves that control involuntary functions, such as vascular tone and sweating. In the foot, this can result in derervation of the sweat glands, resulting in dry and non-sweating skin. Arterial vasoconstriction and dilation may also be impaired, which can lead to blood flowing into the venous system, resulting in distended veins on the dorsum of the foot.</td>
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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...
neuropathy or trauma (Rogers et al 2011). Patients with Charcot foot will present with a red, hot and swollen foot. However, the rarity of this condition, and more common pathologies that have similar signs and symptoms, such as cellulitis and gout, can result in a failure to reach the appropriate diagnosis. Therefore, healthcare practitioners who encounter a patient with this clinical presentation should immediately refer them to the multidisciplinary foot care team (Jarrett 2013).

Figure 1 shows an example of diabetic foot ulceration.

**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

**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

**Figure 1. Diabetic foot ulceration**

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) (Bowling et al 2015, Iqbal et al 2018)

risk factors for foot complications, what their attitude is to these, and what actions they are taking to reduce them, for example wearing appropriate footwear, undertaking daily foot examinations and ensuring effective glycaemic control. 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-Switylk 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 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 cool 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 (Adapted from Diabetes UK 2018)
During the annual foot review, it is important to use a validated screening tool to standardise the review process. For example, the Scottish Care Information-Diabetes Collaboration (SCI-DC) foot screening tool classifies the patient's risk of developing foot complications as low, moderate, high or active, and provides appropriate management interventions that should be taken (Scottish Intercollegiate Guidelines Network (SIGN) 2017).

The patient may be referred to specialist services, such as specialist diabetic foot services, which may include a multidisciplinary foot protection service (Chadwick and Joule 2015), or a vascular or wound care team for limb-threatening foot complications.

The annual foot review should be part of a multidisciplinary team approach to foot care in people with diabetes, enabling any issues to be addressed proactively. The SIGN (2017) guidelines state that this team should include: a diabetes specialist nurse, podiatrist, diabetes physician, orthotist, vascular surgeon, orthopaedic surgeon and radiologist. The annual foot review should be recorded electronically in the patient's notes, so that it can be easily accessed by other members of the multidisciplinary team involved in their care, to ensure continuity of care.

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


