

# Obesity and the diabetic foot

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## Article points

1. The diabetic foot is a spectrum of disorders ranging from feet “at risk” from the effects of peripheral arterial disease and neuropathy, to the ulcerated foot and acute Charcot neuropathic osteoarthropathy.
2. It is clear that a number of different specialists are required to manage all of the different facets of the disease, and for this reason the diabetic foot is best managed by rapid referral to a multi-disciplinary foot care team.
3. People with diabetes who are obese pose a particular challenge in their ability to self-care to prevent disease, in the associated changes in risks and prognosis, and in the choice of diagnostic tests.

## Key words

- Diabetic foot
- Obesity
- Peripheral arterial disease
- Peripheral neuropathy
- Self-care

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**Diabetic foot disease is a serious and expensive problem, nationally and internationally, affecting about 2.5% of people with diabetes at any one time. It is not, however, a single entity but encompasses pathologies such as diabetic neuropathy, peripheral arterial disease, foot ulceration and Charcot neuropathic osteoarthropathy. People with diabetes who are obese may be at particular risk owing to the increased chance of peripheral neuropathy, peripheral arterial disease and inability to self-care. The management of foot ulceration is complex, requiring input from several different specialities. People with diabetes are best served, therefore, by rapid referral to the expert multi-disciplinary foot care team. This article reviews the aetiology and management of the diabetic foot, highlighting areas where obesity may present particular clinical challenges.**

**T**he readership of this journal does not need reminding that parts of the world are facing the dual, and often overlapping, epidemics of obesity and type 2 diabetes. The inevitable outcome of this is that, despite improvements in the management of diabetes, there is still likely to be a disturbing increase in the number of people suffering from the long-term complications of the disease. One of the most disabling of these complications is foot disease.

## Diabetic foot disease – the scale of the problem

Current UK estimates are that approximately 2.5% of people with diabetes will have a foot ulcer at any time, with a further 2.5% having had a previous foot ulcer (Kerr, 2012). This means that at present around 61 000 people with diabetes are estimated to have a foot ulcer within the UK. It is also well known that the risk of lower-extremity amputation (either major [above ankle] or minor [below ankle]) is around 20 times higher in people with diabetes than those without the condition (Kerr, 2012) and that 85% of all amputations are preceded by foot ulceration (Mayfield et al, 1998).

The cost of diabetic foot disease is vast, if both management of ulcers and amputations are taken into account; a recent estimate put the

figure at around £650 million per year in the UK (Kerr, 2012). The personal costs to the affected individuals are even higher. Quality of life is reported as being worse for individuals with an active foot ulcer than those with other chronic diseases such as chronic obstructive pulmonary disease (Kerr, 2012), and lower still if a person has a major amputation (Ragnarson Tennvall and Apelqvist, 2000).

## Risk factors for the development of diabetic foot disease

People with peripheral sensory neuropathy, arteriopathy and deformity are among those most likely to develop foot ulceration (Abbott et al, 2002), and it is these items that are at the core of the screening programme for “at risk” feet in the UK via the Quality and Outcomes Framework incentive scheme for general practitioners (NHS Commissioning Board et al, 2013).

## Peripheral neuropathy

Whilst it is peripheral sensory neuropathy which is tested during screening for the “at risk” foot, motor and autonomic neuropathy also frequently co-exist. The presence of sensory neuropathy means that an individual can traumatise the foot without being aware, whereas motor neuropathy leads to

muscle atrophy, foot deformity and altered pressure distribution across the foot, predisposing the foot to ulceration. Autonomic neuropathy leads to altered regulation of cutaneous blood flow, the loss of sweating and hence dry, fragile skin that is prone to cracking and fissures.

Neuropathy is, of course, one of the “microangiopathic” complications of diabetes and the risk of the development of this complication is related to glycaemic control (American Diabetes Association, 2000). There are other factors, however, that may impinge upon the background of diabetes and make the development of neuropathy more likely. In the UK, among the most commonly seen such factors are the consumption of excess alcohol and vitamin B<sub>12</sub> deficiency (NHS Choices, 2012). Recently, the use of metformin has been recognised as a possible iatrogenic cause for exacerbation of peripheral neuropathy through its effects on vitamin B<sub>12</sub> metabolism. It is not currently recommended that metformin be discontinued, as the resulting areas of benefits from metformin’s effect on glycaemic control are wider than just neuropathy (Wile and Toth, 2010). However, measuring vitamin B<sub>12</sub> levels in people on long-term metformin therapy in whom there is evidence of worsening of neuropathy may be of benefit.

Obesity *per se*, as well as hypertriglyceridaemia, may directly increase the risk of the development of peripheral neuropathy independently of glucose control. There may be differential effects on the small fibres compared with the large fibres, with the latter seeming to be more affected by hyperglycaemia (Smith and Singleton, 2013). This finding of a possible independent role of obesity in peripheral neuropathy risk adds even greater significance to the need to treat weight as well as type 2 diabetes in people with diabetes.

### Peripheral arterial disease

Around one in six people with type 2 diabetes may have peripheral arterial disease (PAD) at diagnosis and this proportion rises to around half in those with comorbid foot ulceration (Hinchliffe et al, 2012). The increased risk of the development of PAD along with other macrovascular diseases in people with type 2 diabetes and obesity is well recognised (e.g. Standl, 2012). In addition, people

with diabetes further increase their risk if they develop renal disease, and this is independent of other known risk factors (O’Hare et al, 2002).

### Triggers of ulceration

Whilst neuropathy and PAD undoubtedly put the person with diabetes at risk of the development of foot disease, the precipitating event is usually traumatic in origin. In the North-West Diabetes Foot Care Study (Abbott et al 2002), in over half the participants the precipitating traumatic event was related to inappropriate or ill-fitting footwear. This can be a particular problem in people with comorbid obesity, who may have significant problems buying shoes that provide a good fit. Individuals with markedly reduced mobility may also be at risk of the development of pressure ulcers, particularly on the heels in my experience.

### Visual disturbance and self-care.

Owing to the shared pathogenic mechanisms, diabetic retinopathy and other complications of diabetes frequently co-exist. It has long been appreciated that visual acuity is an important prerequisite for the ability to perform self-foot inspection and good self-care (Thompson and Masson, 1992). However, for people who are obese, challenges of inspection and other elements of self-care may be compounded by limited flexibility and the inability to wash, or look at, their feet on a daily basis, as recommended by the Diabetes UK Putting Feet First campaign (Diabetes UK, 2012). When discussing foot inspection and self-care, it is important to recognise individuals’ limitations and help put alternative mechanisms into place if necessary. For example, other members of the household could be asked to help with foot washing, or a mirror could be used to look at the plantar aspect of the foot, if the individual has difficulty with flexibility.

### Activity levels

Obesity can be both a consequence and a cause of low levels of physical activity. It is often assumed that a person who does not walk much is at a lower risk of foot ulceration than one who is more active. This may not be the case; one study of a series of individuals with neuropathy showed that it was the people who took the least number of steps

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1. Obesity *per se*, as well as hypertriglyceridaemia, may directly increase the risk of the development of peripheral neuropathy independently of glucose control.
2. This finding of a possible independent role of obesity in peripheral neuropathy risk adds even greater significance to the need to treat weight as well as type 2 diabetes in people with diabetes.
3. The increased risk of the development of peripheral arterial disease along with other macrovascular diseases in people with type 2 diabetes and obesity is well recognised.
4. The precipitating traumatic event for ulceration is often related to inappropriate or ill-fitting footwear; this can be a particular problem in people with comorbid obesity, who may have significant problems buying shoes that provide a good fit.
5. For people who are obese, challenges of inspection and other elements of self-care may be compounded by limited flexibility and the inability to wash, or look at, their feet on a daily basis.

**Page points**

1. People with reduced mobility should be warned against sudden bursts of unaccustomed activity.
2. Perception of the presence of peripheral pulses can be subjective and influenced by many external factors, including obesity.
3. Recent guidelines from the International Working Group of the Diabetic Foot recommend the use of non-removable offloading, such as a total contact cast, as the first-line treatment option.
4. If a total contact cast is not an option, various off-the-shelf below-knee walkers are available, but particular care may be needed in ensuring an appropriate fit for an obese person, and in some cases a good fit may not be achievable.

per day who were at the highest risk of ulceration (Armstrong et al, 2004). What was most remarkable about this study, however, was the finding that it was the variability of daily activity which posed the highest risk for the development of foot ulceration. People with reduced mobility should therefore be warned against sudden bursts of unaccustomed activity.

**Management of the established ulcer**

The same pathological mechanisms – neuropathy and ischaemia – that are responsible for the foot (or feet) of a person with diabetes being “at risk” for the development of ulcers are also frequently responsible for the failure of a wound to heal (Ince et al, 2008). Infection rarely precipitates ulceration as the skin usually provides an effective barrier against bacterial invasion (except in the case of tinea pedis, which causes breaks in the skin) but frequently complicates it and may also prolong the period needed for healing (Prompers et al, 2008). The relative contribution of each of these pathologies varies from individual to individual, and from ulcer to ulcer. As described below, obesity is an important factor contributing to this variation.

**Arterial assessment**

The findings from a simple palpation of pulses has been shown in clinical studies to correlate with outcome (Aubert et al, 2013), but perception of the presence of peripheral pulses can be subjective and influenced by many external factors, including obesity. Given the frequency of arterial disease in people with diabetes and the difficulty of pulse palpation in a substantial number of individuals, a case has been made for every person presenting with a foot ulcer to have an ankle–brachial pressure index (ABPI) measured as part of the initial work-up. While an ABPI of <0.9 definitely indicates ischaemia, calcification of the arteries in diabetes (associated with neuropathy as well as renal impairment [Jeffcoate et al, 2009]) will cause elevation of the ratio even within the normal range (Aubert et al, 2013). Thus, an ABPI measurement has poor sensitivity to pick up significant arterial disease in people with diabetes.

Doppler arterial waveform is another non-invasive tool used to assess the vascular status, and it can be performed with a hand-held Doppler

probe by suitably trained individuals within the clinic setting. The demonstration of a triphasic waveform in peripheral pulses can effectively exclude significant arterial disease in >90% of limbs (Williams et al, 2005). People thought to have PAD who have an open ulcer need urgent assessment by a vascular surgeon.

**Management of the effect of neuropathy: “Offloading”**

It is not so much the neuropathy that needs managing in an individual presenting with a neuropathic ulcer as the effect of the neuropathy on that person’s response to ulceration. An insensate foot can allow an individual to continue to mobilise on an ulcerated area, if it is plantar in location, and to do so in inappropriate footwear. This can cause ongoing trauma to the area and prevent healing. Reducing foot pressures, or “offloading”, is fundamental to the healing of neuropathic foot ulcers. Many different devices are available but their capacity to offload the diabetic foot is variable. Recent guidelines from the International Working Group of the Diabetic Foot recommend the use of non-removable offloading, such as a total contact cast, as the first-line treatment option (Bakker et al, 2012).

If a total contact cast is not an option, various off-the-shelf below-knee walkers are available. Particular care may be needed in ensuring an appropriate fit for an obese person, and in some cases a good fit may not be achievable. If it is, though, and these walkers can be rendered non-removable – in order to enforce compliance – outcome healing rates are improved (Armstrong et al, 2005). The offloading capacity of normal shoes or therapeutic footwear, although important for the prevention of foot ulcers, is not usually sufficient for the healing of neuropathic ulcers, especially when so many other devices have been shown to be effective.

**Infection**

Not only is infection of a foot ulcer negatively associated with healing, it also considerably increases the risk of hospitalisation and amputation (Lavery et al, 2007). The diagnosis of clinical infection is based on signs of inflammation (erythema, warmth, tenderness, pain or induration), although these may be blunted in people with PAD (Lavery et al, 2007).

Clinically non-infected wounds, even if there is surface contamination, should not be treated with antibiotics, to avoid the emergence of multi-drug-resistant organisms.

There is unfortunately no good evidence from randomised trials showing the superiority of any particular antibiotic regimen above any other for the management of clinically infected lesions, and so choices should be made locally, in the knowledge of likely pathogens and known antibiotic resistance patterns. Although some infections are polymicrobial, gram-positive cocci are usually the predominant organisms and empirical antibiotic regimens should take this into account (Lipsky et al, 2012). For mild soft tissue infection 7–10 days' treatment should be adequate, with more serious or deeper infections requiring longer.

### Osteomyelitis

If, in the presence of an infected wound, bone is visible at the base or can be felt when the wound is gently probed with a sterile instrument (i.e. a positive "probe-to-bone test" result) then osteomyelitis is likely. In a non-infected wound, however, a positive probe test result does not mean that bone infection is necessarily present (Lipsky et al, 2012).

The diagnosis of osteomyelitis is often difficult and can be made more problematic by the fact that X-rays may be persistently unchanged (loss of visible cortex on a plain film only occurs after 30–50% of bone mineral has been lost) or that changes may be difficult to distinguish from those seen in Charcot neuropathic osteoarthropathy (covered later). NICE (2011) guidelines suggest that if osteomyelitis is suspected and a plain film is unhelpful then an MRI scan should be performed as this has a sensitivity of around 90% and specificity of about 80% (Dinh et al, 2008). MRI scanners do have size limitations, however. The usual width limit is 60 cm, which might exclude some obese individuals. A labelled white cell scan may be helpful in these circumstances (NICE, 2011).

The choice of primarily medical (i.e. antibiotics alone) as opposed to primarily surgical treatment of osteomyelitis of the diabetic foot is controversial, but studies have shown that infection can be successfully eradicated with antibiotics alone in 60–80% of cases (Game, 2010). The risks associated with prolonged antibiotic therapy (6–8 weeks) must be weighed

up against a combination of those associated with surgery and the risk of development of new ulcers on the foot if its architecture is altered (so-called "transfer ulcers"). Patient preference should also be taken into account here.

### Charcot neuropathic osteoarthropathy

Charcot neuropathic osteoarthropathy, commonly referred to as the "Charcot foot", is a condition affecting the bones, joints and soft tissues of the foot and ankle, which is characterised by inflammation in the earliest phase (Rogers et al, 2011). A complication of peripheral neuropathy, it can be seen in individuals with causes of peripheral neuropathy other than diabetes, although diabetes is still the leading cause in the UK. It is currently thought that the uncontrolled release of pro-inflammatory cytokines (especially interleukin-1 beta and tumour necrosis factor-alpha [Jeffcoate et al, 2005]) following minor trauma or inflammatory insult by another cause (including infection or surgery [Game et al 2012]), along with continued mobilisation on an insensate foot, leads to ongoing bone destruction, subluxation, dislocation and eventual deformity.

Diagnosis is clinical in the first instance and healthcare professionals must be alert to people with neuropathy from any cause presenting with a unilateral inflamed foot. If the person continues to mobilise while investigations are being pursued, further bony damage may occur (Caputo et al, 1998).

It is often thought that obesity may play a part in the onset of the disease because of the increase in forces applied to the foot and ankle. A consensus is yet to emerge on this, but a recent case-control study investigated the relationship between elevated BMI and the development of acute Charcot neuroarthropathy in people with diabetes and found no statistically significant association (Ross et al, 2013).

### Diagnosis

X-rays may be normal in the first instance, show subtle fractures and dislocations or later show more overt fractures and subluxations. If the X-ray is normal, an MRI scan should be performed if possible. If not, a triple-phase bone scan has a similar sensitivity to MRI but is less specific. Computerised tomography scanning may be better at revealing microfractures that were not apparent on plain X-ray

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2. MRI scanners do have size limitations, however. The usual width limit is 60 cm, which might exclude some obese individuals. A labelled white cell scan may be helpful in these circumstances.
3. It is often thought that obesity may play a part in the onset of the disease because of the increase in forces applied to the foot and ankle. A consensus is yet to emerge on this, and the available evidence is somewhat conflicting.

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but will not show the bone oedema associated with active disease (Rogers et al, 2011).

### Management

Offloading is the most important management strategy for the acute Charcot foot and can arrest the progression to deformity. Ideally, the foot should be immobilised in a non-removable cast or walker (Rogers, 2011). If possible, the person with the condition should also use crutches or a wheelchair and should be encouraged to avoid weight-bearing on the affected side. Casting should be continued until the temperature difference between the two feet has settled (Rogers, 2011).

### Conclusion

The diabetic foot is not one single entity but a spectrum of disorders ranging from feet “at risk” from the effects of PAD and neuropathy, to the ulcerated foot and acute Charcot neuropathic osteoarthropathy. The spectrum of disorders is costly to the UK health economy, as it is to the person with the condition, and it is clear that a number of different specialists are required to manage all of the different facets of the disease. It is for this reason that the diabetic foot is best managed by rapid referral to a multi-disciplinary foot care team.

People with diabetes who are obese pose a particular challenge in their ability to self-care to prevent disease, in the associated changes in risks and prognosis, and in the choice of diagnostic tests. ■

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## Online CPD activity

Visit [www.diabetesonthenet.com/cpd](http://www.diabetesonthenet.com/cpd) to record your answers and gain a certificate of participation

Participants should read the preceding article before answering the multiple choice questions below. There is ONE correct answer to each question. After submitting your answers online, you will be immediately notified of your score. A pass mark of 70% is required to obtain a certificate of successful participation; however, it is possible to take the test a maximum of three times. A short explanation of the correct answer is provided. Before accessing your certificate, you will be given the opportunity to evaluate the activity and reflect on the module, stating how you will use what you have learnt in practice. The CPD centre keeps a record of your CPD activities and provides the option to add items to an action plan, which will help you to collate evidence for your annual appraisal.

1. Which SINGLE percentage represents the number of lower leg amputations in people with diabetes that are PRECEDED by foot ulceration?  
Select ONE option only.
  - A. 10%
  - B. 25%
  - C. 33%
  - D. 50%
  - E. 75%
2. Which SINGLE ONE of the following medications potentially EXACERBATES pre-existing diabetic peripheral neuropathy?  
Select ONE option only.
  - A. Aspirin
  - B. Isosorbide mononitrate
  - C. Metformin
  - D. Ramipril
  - E. Simvastatin
3. A 57-year-old man with increasingly painful diabetic neuropathy takes the following medication: aspirin, isosorbide mononitrate, metformin, ramipril and simvastatin.  
Measuring the levels of which ONE of the following may be the most relevant in this situation?  
Select ONE option only.
  - A. Ferrous sulphate
  - B. Folate
  - C. Magnesium
  - D. Vitamin B<sub>12</sub>
  - E. Zinc
4. Which SINGLE percentage represents the estimated number of people with type 2 diabetes and a foot ulcer who have underlying peripheral arterial disease (PAD)?  
Select ONE option only.
  - A. 10%
  - B. 25%
  - C. 33%
  - D. 50%
  - E. 75%
5. According to Diabetes UK, how frequently should people with diabetes routinely check their feet?  
Select ONE option only.
  - A. Twice daily
  - B. Once daily
  - C. Five days a week
  - D. Once weekly
  - E. Once a month
6. A 63-year-old man with type 2 diabetes and a history of mild PAD has an open ulcer on his right hallux. A recent doppler ABPI is 1.1 bilaterally. Which ONE of the following is the SINGLE MOST appropriate management option?  
Select ONE option only.
  - A. Refer to chiropody
  - B. Refer to orthotist
  - C. Refer to podiatrist
  - D. Refer to tissue viability nurse
  - E. Refer to a multi-disciplinary foot clinic
7. A 59-year-old obese woman with type 2 diabetes has a neuropathic foot ulcer. Which ONE of the following is the SINGLE MOST evidence-based form of offloading?  
Select ONE option only.
  - A. Grade 3 compression hosiery
  - B. Moulded insoles
  - C. Orthotic designed shoes
  - D. Removable below-knee walker
  - E. Total contact cast
8. A 79-year-old woman with type 2 diabetes has an infected foot ulcer. She has no known allergies. Which ONE of the following, if any, is the SINGLE MOST evidence-based antibiotic to offer her?  
Select ONE option only.
  - A. Amoxicillin
  - B. Clindamycin
  - C. Erythromycin
  - D. Flucloxacillin
  - E. Phenoxymethylpenicillin
  - F. None of the above
9. A 49-year-old obese man with type 2 diabetes has an infected ulcer on his left fourth toe with a positive "probe-to-bone" test. A foot X-ray is reported as normal.  
According to NICE guidance, which ONE of the following is the MOST appropriate NEXT investigation to confirm or refute the possibility of osteomyelitis?  
Select ONE option only.
  - A. Bone scan
  - B. CT scan
  - C. Labelled white cell scan
  - D. MRI
  - E. Ultrasound
10. A 61-year-old woman is diagnosed with an acute right Charcot foot and immobilisation is advised.  
Select ONE option only.
  - A. 6 weeks
  - B. 12 weeks
  - C. Until there is no temperature difference between both feet
  - D. Until the person reports no pain on weight-bearing
  - E. Until follow-up foot X-rays are reported as normal