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Clinical Review

Managing complications of the diabetic foot

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Summary points

Foot problems occur in around 5% of patients with diabetes each year and cause considerable morbidity and mortality

Problems are caused by peripheral neuropathy or peripheral arterial disease (or both)

Patients with diabetes should be assessed at least once a year for foot pulses, foot sensation, and risk of ulceration

Up to a third of patients with foot ulcers have osteomyelitis, which can be difficult to diagnose

Charcot's neuroarthropathy must be considered in patients presenting with a unilateral hot or swollen foot

Advice and education on foot care are essential for patients with diabetes

Fifteen per cent of patients with diabetes will develop a foot ulcer in their lifetime. Foot complications (box 1) account for more hospital admissions than any other complication of diabetes, with considerable morbidity and mortality.¹ People with diabetes are eight to 24 times more likely than those without diabetes to have a lower limb amputated.² Around 85% of these amputations could be avoided by early detection of foot complications, timely intervention, involvement of a diabetic foot care team, good diabetes control, and patient education.^{3 4} Although we review the various complications separately, patients often have multiple problems.

Sources and selection criteria

We searched Medline and PubMed from 1995 to 2009, focusing on evidence based publications on the diabetic foot and randomised trials for treatment of diabetic foot complications. We supplement these sources with our own knowledge of the literature and selected reviews.

Box 1 Foot complications in diabetes⁵

Peripheral neuropathy (20-40% of patients with diabetes)

Peripheral vascular disease (20-40% of patients with diabetes)

Foot ulceration (5% of patients with diabetes a year)

Foot infection and osteomyelitis (22-66% of all foot ulcers)

Amputation (0.5% of patients with diabetes a year)

Charcot's neuroarthropathy (0.1-0.4% of patients with diabetes a year)

In 1989 the St Vincent Declaration set out the aim of reducing lower limb amputations in people with diabetes by half. In 1992, the Department of Health and Diabetes UK set up a task force to facilitate this aim. Despite this, in the United Kingdom around 0.5% of people with diabetes have a limb amputated each year.⁵ But because amputation rates vary between centres, it is unclear whether improvements have occurred since the task force was established. The National Institute for Health and Clinical Excellence (NICE) has produced guidelines for the diabetic foot (box 2).⁵

Box 2 Summary of NICE guidelines for care of the diabetic foot

- Patients and professionals should share decision making
- Patients should have an annual foot examination that tests foot sensation with a 10 g monofilament or tuning fork, investigates foot pulses, looks for foot deformity, and checks footwear
- Foot risk and care guidelines are as follows:
 1. Low current risk (normal sensation, palpable pulses): requires education and annual review
 2. Increased risk (neuropathy or absent pulses): refer to specialist foot team and review every three to six months
 3. High risk (neuropathy or absent pulses plus deformity, skin change, or previous ulcer): review by foot protection team every one to three months
 4. Foot ulcer: urgent assessment within 24 hours by multidisciplinary team

What predisposes patients with diabetes to develop foot complications (box 3)?

Peripheral neuropathy

At least 28% of people with diabetes have peripheral neuropathy, which affects distal sensory, motor, or

autonomic nerves.⁶ Neuropathy can be extremely painful (burning and allodynia—touch perceived as painful) or painless (numbness), and patients with reduced sensation in their feet may not notice minor injuries. Motor neuropathy results in loss of normal foot shape and abnormal weight bearing, predisposing the foot to injury. Autonomic neuropathy can cause dry cracked skin and vasomotor abnormalities of the microcirculation.

Box 3 Risk factors for diabetic foot ulceration

Peripheral neuropathy

Peripheral vascular disease

Foot deformity

History of foot ulceration

Visual or renal impairment

Advanced age

Living alone

NICE recommends that all patients receive an annual assessment for diabetic peripheral neuropathy and regular advice on foot care (box 4).⁵ Early neuropathy is suggested by callus formation on weight bearing areas. The patient can be examined in clinic by using a 128 Hz tuning fork to check vibration sensation on the apex of the great toe and a 10 g monofilament to test light touch sensation at 10 sites on the foot. These tests can identify 87% of patients with loss of protective sensation in the feet and a risk of ulceration.⁷

Box 4 Important points of information for patients with diabetic foot ulcers

Provide contact details in case a new ulcer develops or an existing one deteriorates

Patients should examine their feet daily for new problems, using mirrors if needed

patients should wear well fitting shoes and not walk barefoot

Regular foot care is needed, including daily washing and careful drying

Maintaining good glycaemic control is important

Every break in the skin is potentially serious if the patient is at high risk of ulceration

Early detection and rapid treatment improve chances of a good outcome

Peripheral arterial disease

Patients with diabetes often have risk factors for peripheral arterial disease, including hypertension, hyperlipidaemia, or smoking, and they have a fourfold increased risk of this complication. The combination of a history of calf pain on walking, absent peripheral pulses, and an ankle-brachial pressure index less than 0.9 predicts the presence of peripheral arterial disease with 95% sensitivity and specificity in these patients.⁸ However, peripheral vascular calcification can falsely raise the ankle-brachial pressure index (>1.3), particularly in patients with diabetes. Colour flow duplex ultrasound is

indicated in any patient with dry gangrene, pain at rest, or a foot ulcer that is slow to heal.⁹

How do you assess a diabetic foot ulcer?

Guidelines devised by the International Working Group on the Diabetic Foot in 2007 stress the importance of inspecting footwear; evaluating the type of ulcer; documenting its location, size, and depth; and checking for infection in patients with a new foot ulcer. Badly fitting footwear can cause ulcers in patients with impaired sensation. Foot ulcers can be classified as ischaemic, neuropathic, or neuroischaemic, and then further classified using the University of Texas wound classification system (table 1), which has been validated in practice (for example, an infected neuroischaemic ulcer penetrating to bone would be IIID).¹⁰

Stage	Grade			
	0	I	II	III
A	Completely epithelialised wound	Superficial wound	Wound penetrates to tendon or capsule	Wound penetrates to bone or joint
B	Plus infection	Plus infection	Plus infection	Plus infection
C	Plus ischaemia	Plus ischaemia	Plus ischaemia	Plus ischaemia
D	Plus infection and ischaemia	Plus infection and ischaemia	Plus infection and ischaemia	Plus infection and ischaemia

wound classification system

When should you suspect infection in the diabetic foot?

Infection in the diabetic foot varies from superficial cellulitis to deeper infection of the soft tissue and bone. Clinical signs of infection include erythema, tenderness, discharge, or localised increase in temperature, but no one sign is a reliable marker of infection. Deranged diabetic control may be the only early marker of infection. White cell count and inflammatory markers may be normal in patients with an infected foot lesion. Probe the ulcer gently to exclude a sinus or tract. If bone can be probed the probability of underlying osteomyelitis is high, with a sensitivity of 66% and specificity of 85% (fig 1).¹¹ On palpation, tenderness or discharge of pus on pressure indicates deep seated infection, and crepitus indicates gas in the tissues, which may indicate a need for urgent surgical intervention.

Fig 1 Probing an ulcer with a sterile probe will detect sinus tracts and underlying osteomyelitis

How is osteomyelitis confirmed?

Osteomyelitis occurs in 22-66% of patients with diabetes and a foot ulcer.¹² The most common organisms cultured are aerobic Gram positive cocci such as *Staphylococcus aureus* or β haemolytic streptococci, but chronic wounds are often polymicrobial, with Gram negative and anaerobic organisms also causing infection. Wound swabs are not useful for demonstrating an underlying infection of bone—pus or bone samples should be obtained. It can be difficult to diagnose osteomyelitis. Plain radiography is the first line test, but the characteristic changes of bone destruction can take two weeks or longer to develop and do not occur until 30-50% of the bone has been destroyed.¹³ Guidelines from the Infectious Diseases Society of America recommend magnetic resonance imaging and bone sampling.¹⁴ Bone scans can aid the diagnosis. Underlying osteomyelitis must be considered in chronic non-healing wounds.

How do you manage symptomatic diabetic peripheral neuropathy?

Various drugs are used to treat peripheral neuropathic pain, particularly in patients with night pain and sleep disturbance. These include tricyclic antidepressants (such as amitriptyline), gabapentin, pregabalin, and duloxetine. Opioid analgesics such as tramadol can also be useful. Patients may need a combination of agents to control the pain.⁷

How do you manage infection in the diabetic foot?

NICE guidelines state that infection in the diabetic foot is a medical emergency and that patients must be referred to a specialist team within 24 hours. Features indicating an emergency referral include new ulceration, new swelling, or new discoloration over part or all of the foot; these may indicate infection or critical limb ischaemia. The Infectious Diseases Society of America and Wound Healing Society have reviewed randomised controlled trial evidence for optimal treatment.^{14 15}

The patient's general medical condition must be assessed and hyperglycaemia, renal failure, or electrolyte disturbance corrected to help eradicate infection and facilitate wound healing. If the patient is systemically unwell, wound and blood cultures must be set up and antibiotics initiated. Systematic reviews have shown that regular debridement of necrotic and devitalised tissue, removal of pus, and off-loading (not allowing the patient to bear their own weight on the foot) aid wound healing.^{16 17} The principles of dressing a healing wound include keeping it moist, managing exudates using appropriate dressings, and protecting the surrounding intact skin.¹⁵ Wounds that fail to heal and those that occur in the presence of peripheral arterial disease should be reviewed by a surgeon.

When starting antibiotics, the most appropriate route, spectrum of activity, and duration of treatment should be considered, according to local policy. If the patient has systemic signs of infection, intravenous antibiotics are needed. Several antibiotics have been shown to be effective in clinical trials, but treatment is often empirical. Most mild infections can be covered with relatively narrow spectrum antibiotics against Gram positive cocci, such as oral amoxicillin-clavulanic acid, flucloxacillin, or oral clindamycin.^{18 19} Ciprofloxacin can be added if Gram negative infection is suspected, although this agent may be linked with *Clostridium difficile* diarrhoea, which can also occur with other antibiotics. In severe infections, initial empirical treatment includes amoxicillin-clavulanic acid, broad spectrum cephalosporins, or clindamycin and ciprofloxacin combinations, preferably parenterally.^{18 19} Evidence from observational studies and randomised trials exists but guidance is still unclear.

In patients with evidence of peripheral arterial disease, revascularisation of the limb should be considered

if the wound is not healing. This can be undertaken endovascularly (angioplasty) or by surgical bypass. A randomised controlled trial of 452 patients found no difference in outcome after either option, although hospital stay was longer in the surgically treated group; however, only 42% of the study population had diabetes.²⁰

What is Charcot's neuroarthropathy?

Charcot's neuroarthropathy is a rare complication in patients with diabetes and peripheral neuropathy.²¹ It is caused by trauma to the foot, which may go unnoticed as a result of neuropathy. In the early stages, the foot becomes swollen, warm ($>2^{\circ}\text{C}$ warmer than the contralateral foot), and erythematous, and the condition can be misdiagnosed as a sprain, gout, deep vein thrombosis, osteomyelitis, or cellulitis. If not treated promptly, osteolysis and osteopenia can occur; ligaments become lax, resulting in gradual remodelling, chronic deformity, and fusion of the bones in abnormal positions. Charcot's neuroarthropathy should be considered in any patient with diabetes who has a red swollen foot when infection is not apparent, because early diagnosis and off-loading can prevent chronic complications from developing (fig 2²²).

Fig 2 Typical deformity of Charcot's foot

How do you diagnose and manage Charcot's neuroarthropathy?

Plain radiographs are the first line investigation and can show various changes, including loss of regular architecture of the foot (fig 3²³). The major differential diagnosis is osteomyelitis, and in the absence of an open wound and with bone destruction on radiography, the likeliest diagnosis is Charcot's neuroarthropathy. If the diagnosis is not clear on plain radiography, magnetic resonance imaging or a leucocyte scan can help differentiate between the two conditions. A leucocyte scan uses radiolabelled white blood cells to illuminate areas of infection, but it cannot distinguish bone infection from soft tissue infection. It is important to remember that both conditions can coexist in the same foot.

Fig 3 Plain radiograph of the foot showing destruction of the metatarsal and tarsal bones (same patient as in fig 2)

Early management aims to prevent further trauma and eliminate stresses by keeping weight bearing to a minimum. A total contact cast or an Aircast, worn continually by the patient, can facilitate this by protecting the foot and reducing skin temperature.^{22 23} Drugs include bisphosphonates, which in randomised controlled trials reduced bone turnover markers such as bone specific alkaline phosphatase compared with placebo, although they did not significantly reduce foot temperature.²³ Surgical fixation is advised if the above measures fail to prevent progressive deformity of the foot and if the joints are unstable. Fixation aims to produce a stable foot with minimal risk of ulceration by the removal and correction of bony deformities. The time frame for this intervention varies depending on local expertise.

When should amputation be considered?

Retrospective observational studies indicate that 15-24% of ulcers result in surgical removal of bone,²⁴ although amputation rates differ between centres depending on the clinical population, stage of presentation of patients with foot complications, local expertise, and the multidisciplinary team's approach. It is important to distinguish between minor and major amputations; removal of a dead or infected digit may be an important part of a treatment plan, but a major amputation is a great setback for

the patient and could often be avoided. In some cases of severe, limb threatening or life threatening foot infection, early amputation may be life saving and lead to a more independent lifestyle later on. A decision to amputate is best made in conjunction with the patient after a discussion that presents all the unique considerations of the case.

Should all patients be managed in a multidisciplinary foot clinic?

NICE guidelines state that “ongoing care of an individual with an ulcerated foot should be undertaken without delay by a multidisciplinary foot care team.”⁹ The team includes specialist podiatrists, nurses, and diabetologists, with additional support from radiology and vascular surgery (fig 4¹⁰). Care in a multidisciplinary clinic reduces major amputations. One large retrospective study showed a 75% reduction in major amputation after introduction of a multidisciplinary foot clinic and improved facilities for revascularisation of ischaemic limbs.⁴ Finally, a foot clinic provides a valuable opportunity for patient education, as suggested in the NICE guidelines (box 4).⁵

Fig 4 Multidisciplinary team: professionals who manage patients with diabetic foot

Tips for non-specialists

Patients with a new foot ulcer, a foot ulcer with osteomyelitis or gangrene, or those with or without a foot ulcer who have cellulitis should be referred to a specialist foot clinic

Patients with pain on resting or intermittent claudication, plus those with an ankle brachial pressure index ≤ 0.5 , should also be referred

Patients with severe infection—systemic toxicity or fever, tachycardia, vomiting, confusion, severe hyperglycaemia, or renal failure—should be admitted to hospital

Patients with peripheral arterial disease and non-healing wounds should be urgently assessed by vascular surgeons

Patients with infection and foot ulcers who are unlikely to comply with outpatient medical treatment and who lack home support will need to be admitted

A hot swollen foot is indicative of Charcot's foot, which needs early diagnosis and treatment to avoid permanent deformity

Additional educational resources

Resources for patients

Patients UK (www.patient.co.uk/health/Diabetes-Foot-Care-A-Summary.htm)—This leaflet summarises how people with diabetes can prevent foot ulcers

Family Doctor (<http://familydoctor.org/online/famdocen/home/common/diabetes/living/352.html>)—Useful tips for patients with diabetes on how to look after their feet

Uptodate (www.uptodate.com/patients/content/topic.do?topicKey=~hL/tcPc67nF2)—Patient

information about foot care in diabetes

Resources for healthcare professionals:

International Working Group on the Diabetic Foot (www.iwgdf.org/)—Extensive information about diabetic foot complications and their management

National Institute for Health and Clinical Excellence (www.nice.org.uk/nicemedia/pdf/CG010NICEguideline.pdf)—UK guidelines on management of foot problems in patients with diabetes

Diabetes UK (www.diabetes.org.uk/Guide-to-diabetes/Treatment_your_health/Monitoring/Feet/)—Useful tips on managing and preventing foot complications in diabetes

Audit Commission (www.audit-commission.gov.uk/SiteCollectionDocuments/AuditCommissionReports/NationalStudies/nrdiabet.pdf)—Testing times: a review of diabetes services in the England and Wales

Scottish Intercollegiate Guidelines Network (www.sign.ac.uk/guidelines/fulltext/55/section7.html)—Scottish guidelines for the management of diabetic foot disease

Notes

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Footnotes

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