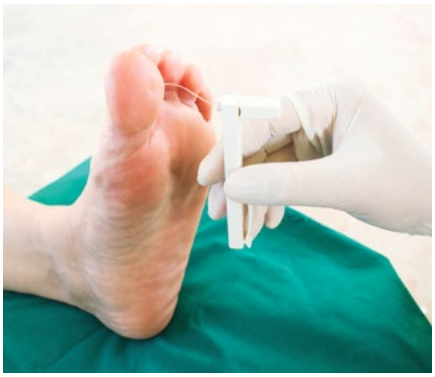
The diabetic foot ulcer



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Background
Diabetic foot ulcers are associated with significant morbidity and mortality and can subsequently lead to hospitalisation and lower limb amputation if not recognised and treated in a timely manner.

Objective
The aim of this article is to review the current evidence for preventing and managing diabetic foot ulcers, with the aim to increase clinicians' confidence in assessing and treating these complex medical presentations.

Discussion
All patients with diabetes should have an annual foot review by a general practitioner or podiatrist. A three-monthly foot review is recommended for any patient with a history of a diabetic foot infection. Assessment involves identification of risk factors including peripheral neuropathy and peripheral vascular disease, and examination of ulceration if present. It is essential to identify patients with diabetes who are 'at risk' of ulceration, assess for any early signs of skin breakdown, initiate appropriate management to prevent progression and refer the patient if indicated.

DIABETIC FOOT ULCERS are a significant cause of morbidity and mortality in the Western world and can be complex and costly.[1] The risk of a patient with diabetes developing a foot ulcer across their lifetime has been estimated to be 19–34%.[2] In addition, the incidence rates for ulcer recurrence remain high: 40% within one year after ulcer healing, and 65% within five years.[2] An annual diabetic foot assessment and optimal management by a multidisciplinary team including general practitioners (GPs) and podiatrists can reduce infection-related morbidities, the need for and duration of hospitalisation and the incidence of major limb amputation.[3,4] A systematic review has shown that initiation of a multidisciplinary team care model resulted in a reduction in major amputations in 94% (31 of 33) of studies.[5] There are many factors involved in the development of foot ulcers in patients with diabetes. The two most important risk factors are peripheral neuropathy (sensory, motor and autonomic) and peripheral vascular disease (PVD). Trauma also plays a significant part in the development of ulceration; in Western countries, the most common cause of trauma is ill-fitting shoes.[6,7] Motor neuropathy results in structural changes in the shape of the foot; consequently, many standard shoes are unsuitable for patients with diabetes. Sensory neuropathy reduces the patient's sensory awareness and thus the patient fails to recognise that the shoe is ill-fitting, resulting in pressure injuries.[6,7]

Lazzarini, Fernando and Netten (2019) have published an acronym – MADADORE – to assist clinicians to remember the recommended diabetic foot ulcer management principles (Figure 1).[8]

The aim of this article is to increase awareness of diabetic foot ulcers among health professionals and to provide structured guidance in preventing and managing patients with diabetic foot ulcer. This is in line with Australian and international guidelines on diabetic foot disease.[9,10]

Risk factors

The risk factors for diabetic foot ulcers include:

- diabetic neuropathy – this is the most common complication of diabetes, affecting up to 50% of patients with type 1 and type 2 diabetes.[11] Peripheral neuropathy can be sensory, motor or autonomic. Sensory neuropathy is usually insidious in nature and can clinically present as positive symptoms such as burning, tingling or paraesthesia

in a stocking-and-glove distribution, or as negative symptoms such as numbness.[11,12] Motor neuropathy typically presents as wasting of the intrinsic muscles of the foot, resulting in clawing of the toes and changes to the architecture of the mid-foot, and subsequently in pressure redistribution over the metatarsal heads. Autonomic neuropathy can contribute to foot ulceration through increased skin atrophy, dry or overly moist skin, hair loss to the legs and ridged/ brittle toenails.[12] Patients with diabetes who have moderate-to-severe sensory loss are seven times more likely to develop their first foot ulcer when compared with patients with diabetes who do not have neuropathy.[13] Other consequences of neuropathy include poor balance due to loss of proprioception, reduced sweating and dry skin that can develop skin cracks and fissures, increasing the risk of developing diabetic foot ulceration.[1,14]

- PVD – patients with diabetes are more susceptible to distal lower limb arterial disease, typically affecting small arteries below the knee and within the foot, resulting in ischaemia.

In summary, neuropathy allows ulceration to develop after unrecognised trauma, whereas poor blood supply (ischaemia) inhibits wound healing. These are compounded by diabetic immunosuppression, resulting in an increased likelihood of severe infections.

Examination

All patients with diabetes should have a foot examination performed annually by their GP or podiatrist. Clinical examination of the diabetic foot is essential for identification of the risk factors that lead to ulceration. Patients with risk factors require more frequent examination – every 1–6 months, depending on severity.[4] The presence of these risk factors will dictate further investigations, management and referral for non-GP specialist care. Ulcer description should include site, size, depth and discharge of wound. Assessing the neuropathic and vascular status of the foot should follow.

Ischaemic wounds commonly occur in the cool, poorly perfused foot, often located in the areas around the lateral fifth metatarsal head and medial first metatarsal head. Identifying the degree of ischaemia is of great importance in wound evaluation. Careful palpation of the pedal pulses (dorsalis pedis and posterior tibial arteries) is necessary. In approximately 12% of the population, the dorsalis pedis artery is absent or markedly reduced in size, so a pulse may not be palpable.[11] A cool foot with no palpable pedal pulses warrants further investigation with non-invasive arterial Doppler ultrasonography studies of the lower limb. Other methods of assessing peripheral perfusion may not be entirely reliable in patients with diabetes. The ankle brachial pressure index (ABI) measurement may be falsely elevated for patients with diabetes because of arterial calcification. Toe pressure measurements are more reliable than ABI measurements in this patient group (Figure 2), although the latest literature indicates that their utility is limited.[15] An absolute toe pressure exceeding 30 mmHg is required for normal wound healing; however, for patients with diabetes, an ABI <0.7 or toe pressure <30–40 mmHg in the presence of a wound warrants a vascular surgical consultation.[10,12,16] These are measures of poor arterial perfusion and are associated with impaired wound healing.[12,16] Asymptomatic PVD (no claudication or ulceration) in a person with diabetes can be managed by observation.

Neuropathic wounds commonly occur in the warm but insensate foot in pressure-bearing areas, often surrounded

M **Metabolic/Medication**
Optimise associated medical conditions, such as hyperglycaemia, hyperlipidaemia and hypertension.

A **Assessment**
Examine diabetic foot ulcer and grade according to PEDIS classification (perfusion, extent [size], depth, infection and sensation).

D **Debridement**
Surgically debride diabetic foot ulcer with necrotic or unhealthy tissue.

A **Antibiotics**
Treat patient with diabetic foot ulcer with appropriate antibiotics on the basis of the severity of the infection.

D **Dressing**
Perform frequent wound care with adequate dressings.

O **Offloading**
Advise patient with diabetic foot ulcer to wear appropriate offloading shoes to reduce plantar pressure.

R **Referral**
Facilitate early referral to a multidisciplinary diabetic foot team for optimal management of diabetic foot ulcer.

E **Education**
Education on foot self-care should be provided to patients with diabetic foot ulcer or associated risk factors.

Figure 1. The MADADORE acronym[8]

by callus tissue. Peripheral neuropathy can be identified on inspection during a neurological examination of the lower limb. Toenails that are abnormally thickened, yellow in colour and crumbling can be evidence of sensory and autonomic neuropathy, or both.[12] Dry and scaly skin with hyperkeratoses on the toes or balls of the feet, or very moist skin are also signs of autonomic neuropathy.[12] Visible channels between the metatarsals are caused by denervation of the lumbricals and interossei, resulting in muscle wasting (Figure 3). Hammer toes are also due to lumbrical denervation (Figure 4).[12] Loss of Achilles reflex is indicative of advanced peripheral neuropathy.[12] Assessment with a tuning fork and light and coarse touch will reveal any sensory neuropathy.[12]

Correct identification of an infected diabetic foot ulcer is critical because, if present with co-existing PVD, it may lead to amputation.[1,12] Any visible bone or bone palpable on probing can confirm a clinical diagnosis of osteomyelitis.[17] Early identification and referral to a podiatrist for regular assessments and customised pressure-offloading footwear is key in the management of neuropathic diabetic ulcers.[18]

Classification of diabetic foot infections

Identification and classification of diabetic foot infections is important, as patients with severe infections require immediate hospitalisation, intravenous (IV) broad-spectrum antibiotics and surgical consultation. Ischaemia of the foot may increase the severity of all grades of infection and warrants prompt referral to a vascular surgical specialist.

Investigations

Superficial swabs are often contaminated with skin flora and are of little value. Deep tissue samples (biopsy, ulcer curettage or aspiration) are superior in diagnosing ulcer infection.[19]

Diagnostic imaging

Plain radiography is the most common first-line radiological investigation in an acute presentation of a diabetic foot ulcer to assess for underlying osteomyelitis. Magnetic resonance imaging is the best imaging modality to diagnose osteomyelitis as it is more sensitive and specific;[12,20] however, it can be of limited availability, is expensive and may not be readily available. Computed tomography scanning with IV contrast is an acceptable alternative when investigating for osteomyelitis.[12] Detailing the patient's diabetic and neuropathic status, the exact anatomical location of the ulcer and whether the ulcer probes to bone will result in a more detailed assessment/radiological report of the area in question when requesting imaging.

Treatment

If there is adequate arterial supply to the foot, treatment of any infection with appropriate antibiotics, debridement of necrotic tissue and pressure offloading, diabetic foot ulcers should heal. Offloading management (removal of pressure from the wound) is crucial for plantar neuropathic ulcers, and patient education is key in successful implementation.

Infection occurs as a result of ulceration and is not a cause thereof.[1] Generally speaking, most diabetic foot infections are polymicrobial and require broad-spectrum antibiotic treatment. Management of mild-to-moderate diabetic foot infections involves the use of oral broad-spectrum antibiotics initially, which are then narrowed following results of cultured deep tissue.[1] Severe infections including cellulitis and osteomyelitis

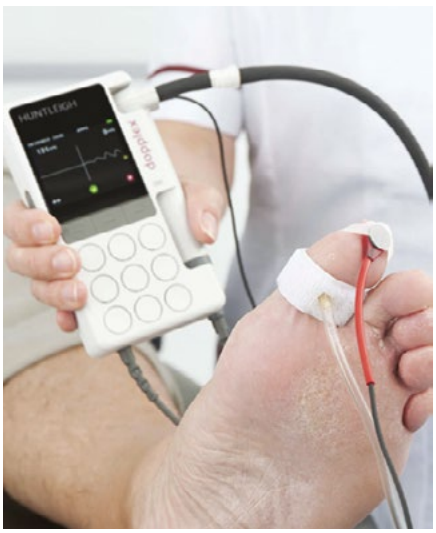

Figure 2. Toe pressure measurement device[22]

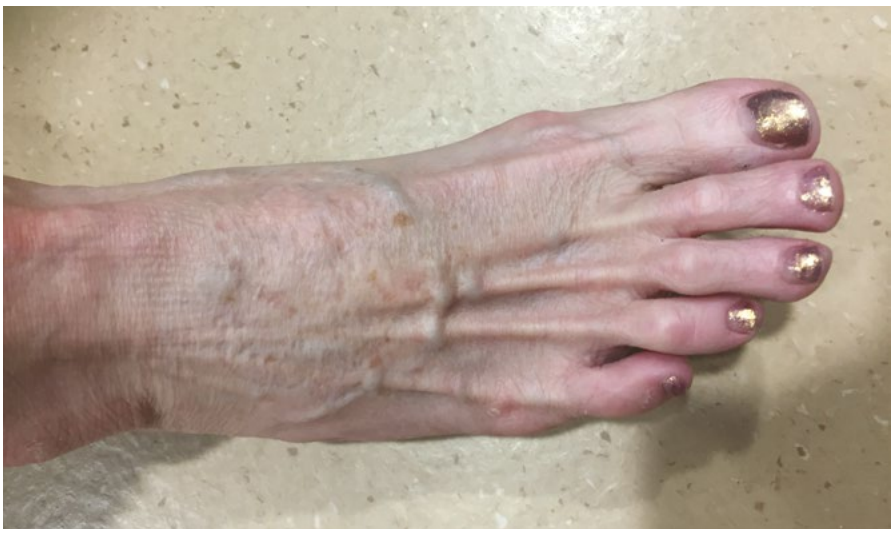

Figure 3. Deep channels between the metatarsals are indicative of lumbrical muscle wasting from denervation

Figure 4. Hammer toe

arequire IV antibiotics initially, with urgent debridement of necrotic tissue. Antibiotics should be continued until the clinical signs of infection have resolved.[1] Optimisation of glycaemic control is very important, as hyperglycaemia impairs wound healing.[1]

There are many diabetic foot ulcer scoring systems available. The PEDIS (perfusion, extent, depth, infection and sensation) classification for diabetic foot ulcers (Tables 1 and 2) was created by the International Working Group of the Diabetic Foot to help clinicians assess risk or prognosis for a person with diabetes and an active foot ulcer and to help communicate within the multidisciplinary team.[19,21]

Table 1. Clinical classification of a diabetic foot infection[21]

Clinical manifestations of infection	Infection severity	PEDIS grade
• Wound without any evidence of purulence or inflammation	Uninfected	1
• Wound associated with ≥2 signs suggestive of inflammation (purulence, erythema, pain, tenderness, warmth or induration) • Extent of erythema limited to ≤2 cm around the ulcer • Superficial infection without evidence of systemic toxicity or local complications	Mild	2
• Wound associated with infection as described above but without signs of systemic illness • Meets ≥1 of the following criteria: erythema >2 cm, lymphangitic streaking, spread beneath the superficial fascia, deep-tissue abscess, gangrene and involvement of muscle, tendon, joint or bone	Moderate	3
• Wound associated with infection • Evidence of systemic toxicity or metabolic instability (eg fever, chills, tachycardia, hypotension, confusion, vomiting, leucocytosis, acidosis, severe hyperglycaemia or azotaemia)	Severe	4

PEDIS, perfusion, extent, depth, infection and sensation

Table 2. The PEDIS classification system[19]

Grade	Perfusion	Extent	Depth	Infection	Sensation
1	No PVD	Skin intact	Skin intact	None	No loss
2	PVD; no CLI	<1 cm	Superficial	Surface	Loss
3	CLI	1–3 cm	Fascia, muscle, tendon	Abscess, fasciitis, septic arthritis	
4		>3 cm	Bone or joint	Systemic inflammatory response syndrome	

CLI, critical limb ischaemia; PEDIS, perfusion, extent, depth, infection and sensation; PVD, peripheral vascular disease

Neuropathic ulcers without infection are best treated by removing the callus tissue around the ulcer and effective pressure offloading. It is recommended that after the wound has healed, offloading should continue for another four weeks to enable scar tissue formation to tolerate future weight bearing. Life-long maintenance of appropriate footwear and patient education is vital to the ongoing prevention of ulceration. Key recommendations include: wearing shoes at all times to avoid incidental trauma, performing a nightly foot self-check for early ulceration or pressure areas, and getting feet measured prior to purchasing shoes to ensure the correct fit. Once a patient has had any kind of diabetic foot infection, they have a higher risk of future ulceration and should be reviewed by a podiatrist regularly.

Referral

The best approach to diabetic foot ulcers involves a multidisciplinary team that can comprise but not be limited to: GPs, endocrinologists, podiatrists, wound care nurses, vascular surgeons and infectious diseases specialists.[5] If there is a wound care clinic available, referral to this service is also advised for ongoing specialist wound management.

Conclusion

An annual foot review is necessary for all patients with diabetes, with more frequent review (1–3-monthly) recommended for any patient with a history of diabetic foot infection. The main aim is to identify patients 'at risk' of ulceration, assess for any early signs of skin breakdown, initiate appropriate management to prevent progression and refer the patient if indicated.

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References

1. Boulton AJM. The diabetic foot. In: Feingold KR, Anawalt B, Boyce A, et al, editors. Endotext [online]. South Dartmouth, MA: MD text.com, 2016.
2. Armstrong DG, Boulton AJM, Bus SA. Diabetic foot ulcers and their recurrence. New Engl J Med 2017;376(24):2367–75. doi: 10.1056/NEJMra1615439.
3. Lipsky BA, Berendt AR, Deery HG, et al. Diagnosis and treatment of diabetic foot infections. Clin Infect Dis 2004;39(7):885–910. doi: 10.1086/424846.
4. Kim PJ, Attinger CE, Evans KK, Steinberg JS. Role of the podiatrist in diabetic limb salvage. J Vasc Surg 2012;56(4):1168–72. doi: 10.1016/j.jvs.2012.06.091.
5. Musuuza J, Sutherland BL, Kurter S, Balasubramanian P, Bartels CM, Brennan MB. A systematic review of multidisciplinary teams to reduce major amputations for patients with diabetic foot ulcers. J Vasc Surg 2019;71(4):1433–46.e3. doi: 10.1016/j.jvs.2019.08.244.
6. Monteiro-Soares M, Boyko EJ, Ribeiro J, Ribeiro I, Dinis-Ribeiro M Predictive factors for diabetic foot ulceration: A systematic review. Diabetes Metab Res Rev 2012;28(7):574–600. doi: 10.1002/dmrr.2319.
7. Bus SA, van Deursen RW, Armstrong DG, Lewis JEA, Caravaggi CF, Cavanagh PR. Footwear and offloading interventions to prevent and heal foot ulcers and reduce plantar pressure in patients with diabetes: A systematic review. Diabetes Metab Res Rev 2016;32 Suppl 1:99–118. doi: 10.1002/dmrr.2702.
8. Lazzarini PA, Fernando ME, Van Netton JJ. Diabetic foot ulcers: Is remission a realistic goal? Endocrinology Today 2019;8(2):22–26.
9. The George Institute, Baker IDI, Adelaide Health Technology Assessment. National evidence-based guideline on prevention, identification and management of foot complications in diabetes. Melbourne: Baker IDI, 2011.
10. The International Working Group on the Diabetic Foot. IWGDF guidelines on the prevention and management of diabetic foot disease. IWGDF, 2019.
11. Boulton AJM. The diabetic foot. In: DeGroot LJ, Chrousos G, Dungan K. Endotext [online]. South Dartmouth, MA: MD text.com, 2016.
12. Sunshein KF, Samouilov A. Peripheral neuropathy and the diabetic foot. Emergency Medicine Reports 2017. Available at www.reliasmedia.com/articles/140228-peripheral-neuropathy-and-the-diabetic-foot [Accessed 10 February 2020].
13. Calhoun JH, Cantrell J, Cobos J, et al. Treatment of diabetic foot infections: Wagner classification, therapy, and outcome. Foot Ankle 1988;9(3):101–06. doi: 10.1177/107110078800900301.
14. Boulton AJM. Diabetic neuropathy and foot complications. Handb Clin Neurol 2014;126:97–107. doi: 10.1016/B978-0-444-53480-4.00008-4.
15. Abouhamda A, Alturkstani M, Jan Y. Lower sensitivity of ankle-brachial index measurements among people suffering with diabetes-associated vascular disorders: A systematic review. SAGE Open Med 2019;7:2050312119835038. doi: 10.1177/2050312119835038.
16. Sibley RC 3rd, Reis SP, MacFarlane JJ, Reddick MA, Kalva SP, Sutphin PD. Noninvasive physiologic vascular studies: A guide to

diagnosing peripheral arterial disease. Radiographics 2016;37(1):346–57. doi: 10.1148/rg.2017160044.

17. Lam K, van Asten SAV, Nguyen T, La Fontaine J, Lavery LA. Diagnostic accuracy of probe to bone to detect osteomyelitis in the diabetic foot: A systematic review. Clin Infect Dis 2016;63(7):944–48. doi: 10.1093/cid/ciw445.
18. Clarke EAM, Tsubane M. The role of the podiatrist in managing the diabetic foot ulcer. Wound Healing Southern Africa 2008;1(1):40–42.
19. Chuan F, Tang K, Jiang P, Zhou B, He X. Reliability and validity of the perfusion, extent, depth, infection and sensation (PEDIS) classification system and score in patients with diabetic foot ulcer. PloS One 2015;10(4):e0124739. doi: 10.1371 journal.pone.0124739.
20. Peters EJ. Pitfalls in diagnosing diabetic foot infections. Diabetes Metab Res Rev 2016;32 Suppl 1:254–60. doi: 10.1002/dmrr.2736.
21. Schaper NC, Apelqvist J, Bakker K. The international consensus and practical guidelines on the management and prevention of the diabetic foot. Curr Diab Rep 2003;3(6):475–79. doi: 10.1007/s11892-003-0010-4.
22. Huntleigh Healthcare Ltd. Dopplex ATP ankle and toe pressure kit. Cardiff: Huntleigh Healthcare Ltd, 2020. Available at www.huntleigh-diagnostics.com/store/vascular-assessment/assessment-by-dopplex/dopplers-kits/dopplex-atp-kit [Accessed 10 February 2020].

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