Introduction

Foot complications are among the most serious and costly complications of diabetes mellitus. Amputation of the lower extremity or part of it is usually preceded by a foot ulcer. A strategy that includes prevention, patient and staff education, multidisciplinary treatment of foot ulcers, and close monitoring can reduce amputation rates by 49–85%. Therefore, several countries and organizations, such as the World Health Organization and the International Diabetes Federation, have set goals to reduce the rate of amputations by up to 50%.

The basic principles of prevention and treatment described in these guidelines are based on the International Consensus on the Diabetic Foot. Depending on local circumstances, these principles have to be translated for local use, taking into account regional differences in socio-economics, accessibility to health care, and cultural factors. These practical guidelines are aimed at healthcare workers involved in the care of people with diabetes. For more details and information on treatment by specialists in foot care, the reader is referred to the International Consensus document.

Pathophysiology

Although the spectrum of foot lesions varies in different regions of the world, the pathways to ulceration are probably identical in most patients. Diabetic foot lesions frequently result from two or more risk factors occurring together. In the majority of patients, diabetic peripheral neuropathy plays a central role: up to 50% of people with diabetes with type 2 diabetes have neuropathy and at-risk feet.

Neuropathy leads to an insensitive and sometimes deformed foot, often with an abnormal walking pattern. In people with neuropathy, minor trauma – caused, for example, by ill-fitting shoes, walking barefoot, or an acute injury – can precipitate a chronic ulcer. Loss of sensation, foot deformities, and limited joint mobility can result in abnormal biomechanical loading of the foot. Thickened skin (callus) forms as a result. This leads to a further increase of the abnormal loading and, often, subcutaneous haemorrhage.

Whatever the primary cause, the patient continues walking on the insensitive foot, impairing subsequent healing (Figure 1). Peripheral vascular disease, usually in conjunction with minor trauma, may result in a
painful, purely ischaemic foot ulcer. However, in patients with both neuropathy and ischaemia (neuropathic ulcer), symptoms may be absent, despite severe peripheral ischaemia. Microangiopathy should not be accepted as a primary cause of an ulcer.

**Cornerstones of foot management**

There are five key elements that underpin foot management:

1. Regular inspection and examination of the at-risk foot
2. Identification of the at-risk foot
3. Education of patient, family, and healthcare providers
4. Appropriate footwear
5. Treatment of nonulcerative pathology

**Regular inspection and examination**

All people with diabetes should be examined at least once a year for potential foot problems. Patients with demonstrated risk factor(s) should be examined more often – every 1–6 months. The absence of symptoms does not mean that the feet are healthy; the patient might have neuropathy, peripheral vascular disease, or even an ulcer without any complaints. The patient’s feet should be examined with the patient lying down and standing up, and their shoes and socks should also be inspected.

**Identification of the at-risk foot**

After examination of the foot, each patient can be assigned to a risk category, which should guide the subsequent management (Figure 2).

**Progression of risk categories**

- Sensory neuropathy and/or foot deformities or bony prominences and/or signs of peripheral ischemia and/or previous ulcer or amputation
- Sensory neuropathy
- Non-sensory neuropathy
Education for patients, family, and healthcare providers

Education, presented in a structured and organized manner, plays an important role in the prevention of foot problems. The aim is to enhance motivation and skills. People with diabetes should learn how to recognize potential foot problems and be aware of the steps they need to take in response. The educator must demonstrate the skills, such as how to cut nails appropriately. Education should be provided in several sessions over time, preferably using a mixture of methods. It is essential to evaluate whether the person with diabetes has understood the messages, is motivated to act, and has sufficient self-care skills. An example of instructions for the high-risk patient and family is given in the succeeding part of this article. Furthermore, physicians and other healthcare professionals should receive periodic education to improve care for high-risk individuals.

Items that should be covered when instructing the high-risk patient are as follows:

- Daily feet inspection, including areas between the toes
- The need for another person with skills to inspect feet, should the people with diabetes be unable to do so. (If vision is impaired, people with diabetes should not attempt their own foot care.)
- Regular washing of feet with careful drying, especially between the toes
- Water temperature, which should always be below 37°C
- Not using a heater or a hot-water bottle to warm ones feet
- Avoidance of barefoot walking indoors or outdoors and of wearing of shoes without socks
- Chemical agents or plasters to remove corns and calluses, which should not be used
- Daily inspection and palpation of the inside of the shoes
- Not wearing tight shoes or shoes with rough edges and uneven seams
- Use of lubricating oils or creams for dry skin, but not between the toes
- Daily change of socks
- Wearing of stocking with seams inside out or preferably without any seams
- Never wearing tight or knee-high socks.
- Cutting nails straight across (Figure 3)

- Corns and calluses, which should be cut by a healthcare provider
- Patient awareness of the need to ensure that feet are examined regularly by a healthcare provider
- Notifying the healthcare provider at once if a blister, cut, scratch, or sore has developed

Appropriate footwear

Inappropriate footwear is a major cause of ulceration. Appropriate footwear should be used both indoors and outdoors and should be adapted to the altered biomechanics and deformities – essential for prevention. Patients without loss of protective sensation can select off-the-shelf footwear by themselves. In patients with neuropathy and/or ischaemia, extra care must be taken when fitting footwear – particularly when foot deformities are also present. The shoe should not be too tight or too loose (Figure 4). The inside of the shoe should be 1–2 cm longer than the foot itself. The internal width should be equal to the width of the foot at the site of the metatarsal phalangeal joints, and the height should allow enough room for the toes. The fit must be evaluated with the patient in standing position, preferably at the end of the day. If the fit is too tight because of deformities or if there are signs of abnormal loading of the foot (e.g. hyperaemia, callus, ulceration), patients should be referred for special footwear (advice and/or construction), including insoles and orthoses.
Treatment of nonulcerative pathology

In a high-risk patient, callus and nail and skin pathology should be treated regularly, preferably by a trained foot care specialist. If possible, foot deformities should be treated nonsurgically (e.g. with an orthosis).

Foot ulcers

A standardized and consistent strategy for evaluating wounds is essential and will guide further therapy. The following items must be addressed.

Cause

Ill-fitting shoes are the most frequent cause of ulceration, even in patients with ‘pure’ ischaemic ulcers. Therefore, shoes should be examined meticulously in all patients.

Type

Most ulcers can be classified as neuropathic, ischaemic, or neuro-ischaemic. This will guide further therapy. Assessment of the vascular tree is essential in the management of a foot ulcer.

If one or more pedal pulses are absent, or if an ulcer does not improve despite optimal treatment, more extensive vascular evaluation should be performed. As a first step, the ankle brachial pressure can be measured. An ankle brachial pressure index less than 0.9 is a sign of peripheral arterial disease. However, ankle pressure might be falsely elevated because of calcification of the arteries. Preferably, other tests, such as measurements of toe pressure or transcutaneous pressure of oxygen (TcPo2), should be used. Figure 5 gives an estimate of the chance of healing using the tests. If a major amputation is being contemplated, the option of revascularization should be considered first.

Noninvasive evaluation and estimate of probability of healing:

Site and depth

Neuropathic ulcers frequently occur on the plantar surface of the foot or in areas overlying a bony deformity. Ischaemic and neuro-ischaemic ulcers are more common on the tips of the toes or the lateral border of the foot.

The depth of an ulcer can be difficult to determine because of the presence of overlying callus or necrosis. Therefore, neuropathic ulcers with callus and necrosis should be debrided as soon as possible. This debridement should not be performed in ischaemic or neuro-ischaemic ulcers without signs of infection. In neuropathic ulcers, debridement can usually be performed without (general) anaesthesia.

Signs of infection

Infection of the foot in a person with diabetes presents a serious threat to the affected limb and should be evaluated and treated promptly. Infection is diagnosed by the presence of signs and/or symptoms of inflammation, but these may be blunted by neuropathy or ischemia, and systemic findings (e.g. fever, increased white blood count) are often absent. Infections should be classified as mild (superficial with minimal cellulitis), moderate (deeper or more extensive), or severe (accompanied by systemic signs of sepsis). If not properly treated, infection can spread to underlying tissues, including the bone.

Patients with a diabetic foot infection should be assessed for the presence of osteomyelitis. When there is a deep wound overlying the bone, especially if it is longstanding and it is possible to touch the bone with a sterile probe, osteomyelitis is likely.

Properly obtained specimens for Gram stain and culture of deep tissue are advised; avoid superficial swabs. Mild (superficial and limited) infection is usually caused by aerobic Gram-positive cocci, especially *Staphylococcus aureus*. Chronic infections and infections that are more severe are often polymicrobial with aerobic Gram-negative rods and anaerobes.

Ulcer treatment

If treatment is based on the principles outlined in the succeeding part of this article, healing can be achieved in the majority of patients. Optimum wound care cannot compensate for continuing trauma to the wound bed or for ischaemia or infection. Patients with an ulcer deeper than the subcutaneous tissues should be treated intensively, and, depending on local resources and infrastructure, hospitalization must be considered.

Principles of ulcer treatment

- Relief of pressure and protection of the ulcer
  - Mechanical off-loading – the cornerstone in ulcers with increased biomechanical stress
Management and Prevention of the Diabetic Foot

1. Total contact casting or other casting techniques – preferable in the management of plantar ulcers
2. Temporary footwear
3. Individually moulded insoles and fitted shoes
4. Non-weight bearing
   - limitation of standing and walking
   - crutches, etc.

- Restoration of skin perfusion
  - Peripheral arterial disease is the most important factor relating to the outcome of a diabetic foot ulcer. Healing will be severely impaired in diabetic patients with a foot ulcer in case of symptoms or signs of ischemia, an ankle brachial pressure index <0.6, toe pressures <50 mmHg, or TcPo2 <30 mmHg. In these patients, revascularization should always be considered.
  - The benefits of pharmacological treatment to improve perfusion have not been established
  - Emphasis should be placed on cardiovascular risk reduction (cessation of smoking, treatment of hypertension and dyslipidaemia, use of aspirin)

- Treatment of infection
  - Superficial ulcer with skin infection
    - Cleanse, debride all necrotic tissue and surrounding callus
    - Start empiric oral antibiotic therapy targeted at S. aureus and streptococci
  - Deep (potentially limb-threatening) infection
    - Urgently evaluate for surgical drainage to remove necrotic tissue, including infected bone, and drain abscesses
    - Consider need for arterial revascularization
    - Initiate empiric, parenteral broad-spectrum antibiotic therapy aimed at Gram-positive and Gram-negative bacteria, including anaerobes

- Metabolic control and treatment of comorbidity
  - Optimal diabetes control, if necessary with insulin (blood glucose <8 mmol/L or <140 mg/dL)
  - Treatment of oedema and malnutrition

- Local wound care
  - Frequent wound inspection
  - Frequent wound debridement (with scalpel)
  - Control of exudate and maintenance of moist environment
  - Consideration of negative pressure therapy in post-operative wounds

The following treatments are not established in routine management:
- Biological active products (collagen, growth factors, bio-engineered tissue) in neuropathic ulcers
- Systemic hyperbaric oxygen treatment
- Silver or other anti-microbial agents containing dressings

Note: footbaths are contra-indicated as they induce maceration of the skin.
- Education for patient and relatives
  - Instruction should be given on appropriate self-care and how to recognize and report signs and symptoms of (worsening) infection – fever, changes under local wound conditions, or hyperglycaemia
- Determining the cause and preventing recurrence
  - The cause of the ulceration should be determined to reduce the chance of recurrences. Ulcers on contra-lateral foot should be prevented and heel protection provided during periods of bed rest. Once the episode is over, the patient should be included in a comprehensive foot care programme with life-long observation

Organization

Effective organization requires systems and guidelines for education, screening, risk reduction, treatment, and auditing. Local variations in resources and staffing will often determine the ways in which care is provided. Ideally, a foot care programme should provide the following:

- Education for patients, carers and healthcare staff in hospitals, primary health care, and the community
- A system to detect all people who are at risk, with annual foot examination of all known patients
- Measures to reduce risk, such as podiatry and appropriate footwear
- Prompt and effective treatment
- Auditing of all aspects of the service to ensure that local practice meets accepted standards of care
- An overall structure that is designed to meet the needs of patients requiring chronic care rather than simply responding to acute problems when they occur

In all countries, at least three levels of foot care management are needed:

| Level 1 | General practitioner, podiatrist, and diabetic nurse |
| Level 2 | Diabetologist, surgeon (general and/or vascular and/or orthopaedic), podiatrist, and diabetic nurse |
| Level 3 | Specialized foot centre with multiple disciplines specialized in diabetic foot care |

Setting up a multidisciplinary foot care team has been found to be accompanied by a drop in the number of amputations. If it is not possible to create a full team from the outset, this should be built up step by step, introducing the various different disciplines at different stages. This team must work in both primary and secondary care settings. Ideally, a foot care team would consist of a diabetologist, surgeon, podiatrist, orthotist, educator, and plaster technician, in close collaboration with an orthopaedic, podiatric and/or vascular surgeon, and dermatologist.
Addendum

Sensory foot examination

Neuropathy can be detected using the 10-g (5.07 Semmes–Weinstein) monofilament, tuning fork (128 Hz), and/or cotton wisp.

Semmes–Weinstein monofilament

• Sensory examination should be carried out in a quiet and relaxed setting. First, apply the monofilament on the patient’s hands (or elbow or forehead) so that he or she knows what to expect.
• The patient must not be able to see whether or where the examiner applies the filament. The three sites to be tested on both feet are indicated in Figure 6.
• Apply the monofilament perpendicular to the skin surface (Figure 7(A)).
• Apply sufficient force to cause the filament to bend or buckle (Figure 7(B)).
• The total duration of the approach – skin contact and removal of the filament – should be approximately 2 s.
• Apply the filament along the perimeter of, not on, an ulcer site, callus, scar, or necrotic tissue.
• Do not allow the filament to slide across the skin or make repetitive contact at the test site.
• Press the filament to the skin and ask the patient whether they feel the pressure applied (‘yes’/’no’) and, next, where they feel the pressure (‘left foot’/’right foot’).
• Repeat this application twice at the same site, but alternate this with at least one ‘mock’ application in which no filament is applied (total three questions per site).
• Protective sensation is present at each site if the patient correctly answers two out of three applications. Protective sensation is absent with two out of three incorrect answers – the patient is then considered to be at risk of ulceration.
• Encourage the patients during testing by giving positive feedback.
• The healthcare provider should be aware of the possible loss of buckling force of the monofilament if used for too long.

Tuning fork

• The sensory examination should be carried out in a quiet and relaxed setting. First, apply the tuning fork on the patient’s wrists (or elbow or clavicle) so that he or she knows what to expect.
• The patient must not be able to see whether or where the examiner applies the tuning fork. The tuning fork is applied on a bony part on the dorsal side of the distal phalanx of the first toe.
• The tuning fork should be applied perpendicularly with constant pressure (Figure 8).
• Repeat this application twice, but alternate this with at least one ‘mock’ application in which the tuning fork is not vibrating.
The test is positive if the patient correctly answers at least two of three applications and negative (‘at risk for ulceration’) with two of three incorrect answers.

If the patient is unable to sense the vibrations on the big toe, the test is repeated more proximally (malleolus, tibial tuberositas).

Encourage the patient during testing by giving positive feedback.

**Easy-to-use foot screening assessment sheet for clinical examination**

| Deformity or bony prominences | Yes/No |
| Skin not intact (ulcer)        | Yes/No |
| Neuropathy                     |        |
| Monofilament undetectable      | Yes/No |
| Tuning fork undetectable       | Yes/No |
| Cotton wool undetectable       | Yes/No |
| Abnormal pressure, callus      | Yes/No |
| Loss of joint mobility         | Yes/No |
| Foot pulses                    |        |
| Tibial posterior artery absent  | Yes/No |
| Dorsal pedal artery absent     | Yes/No |
| Discoloration on dependency    | Yes/No |
| Any others                     |        |
| Previous ulcer                 | Yes/No |
| Amputation                     | Yes/No |
| Inappropriate footwear         | Yes/No |

**Conflict of Interest**

None declared.