Best Practice Recommendations For Skin Health and Wound Management 2025

CHAPTER 11

Prevention and Management of Diabetic Foot Ulcers

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INTRODUCTION

Diabetes mellitus (DM) is a complex, chronic metabolic disorder characterized by hyperglycemia that leads to microvascular, macrovascular and neuropathic complications.[1] Diabetes Canada states there were more than, "5.7 million Canadians living with diabetes (type 1 & type 2 diagnosed + type 2 undiagnosed), however there are 11.7 million Canadians living with diabetes or prediabetes a condition that, if left unmanaged, can develop into type 2 diabetes".[2] They further state that approximately $30 billion per year is spent on diabetes services. The high prevalence of diabetes and its overwhelming impact on patients, care partners, communities and the health-care system are a significant issue that require all levels of government to be engaged.[2]

In Canada, populations at higher risk for developing type 2 DM include those of African, Arab, Hispanic, Indigenous or South Asian descent.[3] Rates of DM are significantly higher in Indigenous populations, an issue compounded by unique barriers to care including, but not limited to, colonization effects, a lack of cultural competency among health-care providers, jurisdictional issues, limited access to care, geographical location, food security and language barriers.[4]

Ulcers and Lower Limb Amputations

The lifetime risk for foot ulceration in people with diabetes is higher, at 19–35%, compared with the general population, with a yearly incidence in higher income countries of 2.4%.[5] The Canadian Institute for Health Information (CIHI) states "diabetes accounts for about two-thirds of lower limb amputations in Canada"219 CIHI data from 2020 to 2023 indicates that there are approximately 7,720 hospitalizations each year related to diabetes-associated lower limb amputations, with 3,080 involving major leg amputations. These cases often result in extended hospital stays, averaging 19 days per admission, with each hospitalization costing around $47,000. Collectively, the healthcare costs associated with diabetic foot ulcers and amputations amount to $750 million annually.[219]

According to the International Diabetes Federation's *Atlas Reports,* persons with diabetes are 15 to 40 times more likely to require lower limb amputation compared with the general population.[6] Up to 25% of the nearly 5.7 million Canadians living with diabetes will develop a diabetic foot ulcer (DFU) in their lifetime. As well, approximately 85% of amputations are preceded by the development of a neuropathic foot ulcer[7] and are preventable.[219]

Lower limb amputations (LLAs) related to diabetes mellitus are increasing worldwide.[1] Diabetes Canada states 85% of diabetes-related amputations are preventable through risk screening for diabetes and peripheral arterial disease (PAD), as well as patient education focused on management of blood glucose, nutrition, physical activity, foot care, footwear and mental health.[8] Prevention initiatives must attend to patient health literacy, access to care (equity) and social determinants of health.[9] Of concern, a patient who develops a diabetic foot ulcer spends, on average, five days in the hospital if the ulcer heals as expected, yet, if the ulcer does not heal and progresses to an amputation the hospital length of stay increases to 70 days.[10] Diabetic foot ulcers incur inpatient hospital costs of $23,000 CDN (mean cost per patient) and costs more than double, up to $49,000 if amputation is required.[11] This is costly to the patient, care partners, families, employers, communities and the health-care system.[12]

Following a lower limb amputation, people with diabetes suffer psychological, spiritual, emotional and physical consequences of limb loss.[13] Armstrong et al. state the five-year mortality rates are as follow: Charcot (29%), diabetic foot ulcer (30.5%), minor (46.2%) and major amputations (56.6%) respectively. This is a higher mortality rate than is seen in breast cancer (9%).[5] As well, the foot ulcer recurrence rate is 60% at 12 months and 65% at 5 years; these are alarming statistics.[14]

Therefore, proactive and preventative risk screening and foot health initiatives (skin/nail care, footwear, pre-ulcer assessment) should be major considerations for people with diabetes, families and care partners, communities and health-care professionals who partner with patients and/or provide care. Foot complications in high-risk populations can lead to a cascade of negative diabetes-related foot complications, potentially resulting in decline in function, infection and loss of limb and life.[14] Armstrong et al. report the mortality rates for individuals with a foot ulcer is 231/1000 compared to 182/1000 deaths for persons with diabetes without foot ulcers.[14] McDermott et al. state, "Morbidity following incident ulceration is high, with recurrence rates of 65% at 3–5 years, lifetime lower-extremity amputation incidence of 20%, and 5-year mortality of 50–70%".[12]

Identifying and addressing the high-risk foot is cost saving to the health-care system and highly feasible, even in low-and middle-income countries.[15,16] Once an ulcer develops, timely access to care is required to prevent infection, amputation, changes to the patient's quality of life and strain on the health-care system.[17]

The International Working Group on the Diabetic Foot (IWGDF) identifies key elements to successful system-wide diabetes-related foot care. These are essential to the establishment of prevention, early detection, then treatment and long-term management. Plans of care and early detection should include: education, risk-detection systems, access to risk-reduction measures, prompt and effective ulcer and infection treatment, vascular and surgical expertise, offloading modalities, wound care access, and auditing of services.[1]

Canadian Perspective

Canada fares worse compared with the United Kingdom, where annual diabetic foot screening prevalence is 70–80%. In Canada, Patel et al. (2022) reported the current national frequency of annual diabetic foot screening is uncertain and may well be below 50%.[18]

Therefore, multidisciplinary teams must come together to continue to lower amputation rates.[14] In Canada, Hwang (2023) explored the referral times for patients (n=20) with high-risk wounds. Through early identification and treatment of patients identified at high-risk, the team was able to reduce (56.3%) average referral times, improve healing times, reduce the numbers of home care visits and suggest the potential for significant cost avoidance.[19]

The negative cascade of diabetic foot complications persists despite the many treatment modalities available for foot care of individuals with diabetes and its related conditions. In addition, public and professional awareness of optimal care is poor.[20] In response, Wounds Canada collaboratively developed and released the *Foot Health Pathway for People Living with Diabetes: Integrating a Population Health Approach*.[129] This pathway highlights the importance of, "upstream preventative care, timely detection and immediate intervention for pathology as well as the implementation of activities to prevent wound deterioration and recurrences".[17]

This chapter is written with the intent to encompass the quintuple aim for health-care improvement: to enhance the patient experience, reduce costs, improve population health, improve the clinician experience and enhance equity (See Table 1). The equity component is particularly important for patients living with skin issues, wounds and, specifically, diabetes-related foot ulcers. Ensuring all patients receive care, supplies and ongoing preventative strategies needs to be recognized and communicated to policy makers.[20]

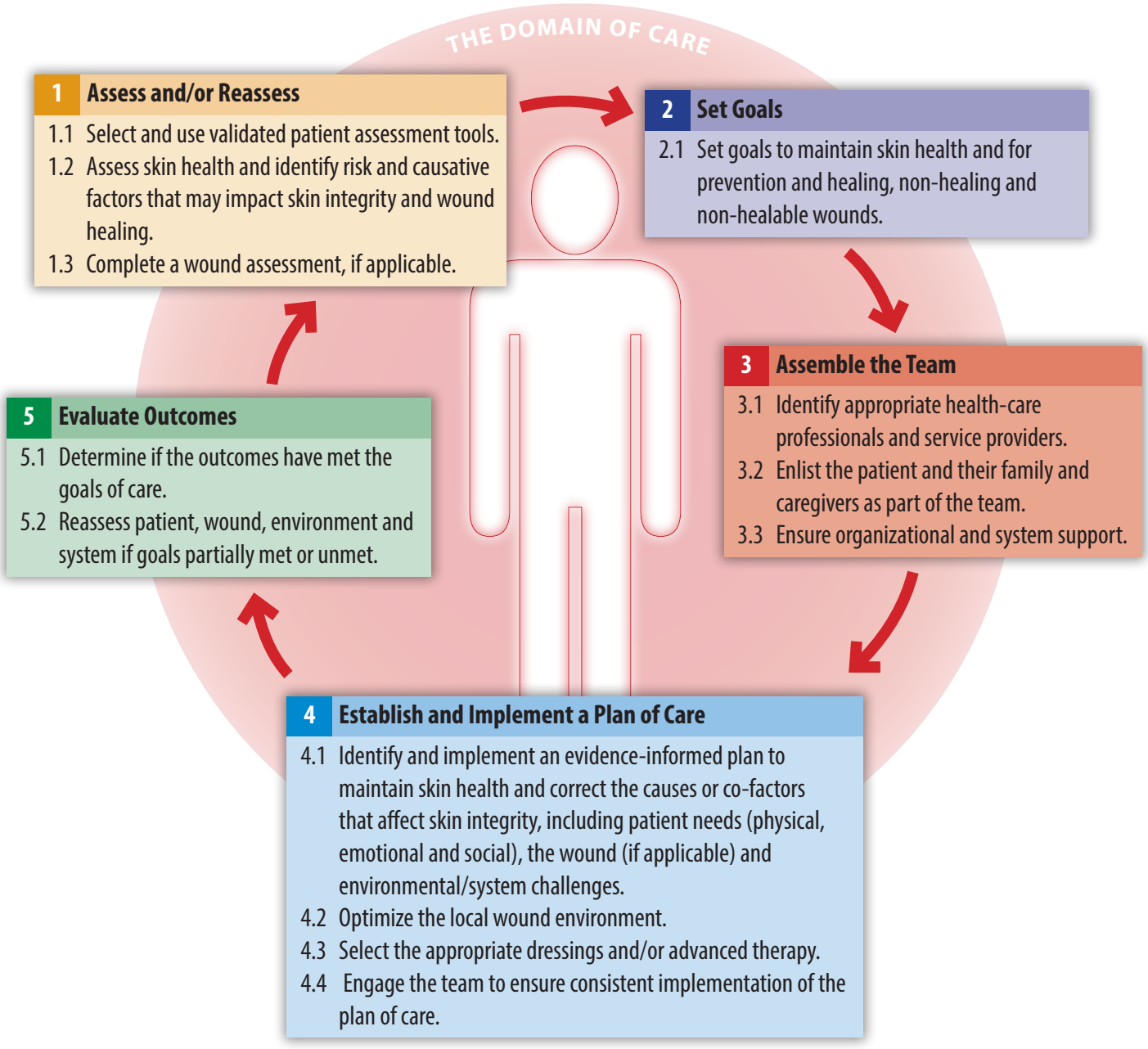
Table 1: Quintuple aim and management of Diabetic Related Foot Ulcers

5 Components	Applied to Diabetic Foot Ulcers
Improving population health	Through risk screening, prevention, education and self-management strategies Adopt Foot Health Pathway, focused on prevention and timely intervention[17] Establish care pathways for individuals with diabetic foot problems who need inpatient care[22]
Reducing costs	Application of best practice to ensure prevention and most effective treatment Appropriate use of resources such as foot care, footwear, nutrition, self-management, offloading, dressings
Advancing health equity	Provide, "care within 24 hours of a person with diabetic foot problems being admitted to hospital, or the detection of diabetic foot problems (if the person is already in hospital)"[22] Application of principles of equity to all those at risk for, or affected by, diabetes mellitus disease
Care team well-being	Provide clinically usable information for frontline clinicians Prevent morale injury by supporting frontline clinicians with best-practice-based policies
Enhancing the patient experience	Provide a supportive process of care for all those with diabetes-related foot ulcers

THE WOUND PREVENTION AND MANAGEMENT CYCLE

This chapter offers a practical, easy-to-follow guide that incorporates the best available evidence. It outlines a process, or series of consecutive steps, that supports patient-centred care. This process, called the *Wound Prevention and Management Cycle* (See Figure 1) guides the clinician through a logical and systematic method for developing a customized plan for the prevention and management of complications and wounds from the initial assessment to a sustainable plan targeting self-management for the patient.

Figure 1: The Wound Prevention and Management Cycle



The recommendations in this chapter are based on the best available evidence and are intended to support the clinician, patient, care partners, their family and health-care team in planning and delivering the best clinical practice. Two foundational chapters supplement this chapter with additional evidence, informed information and recommendations that are general to all wound types: Chapter 3: Skin: Anatomy, Physiology and Wound Healing[23] and Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[24]

There are three guiding principles within the best practice recommendations (BPRs) that support effective prevention and management of skin breakdown:

1. The use of the *Wound Prevention and Management Cycle*, regardless of the specifics, to prevent and manage skin breakdown
2. The constant, accurate and multidirectional flow of meaningful information within the team and across all care settings, and
3. The patient as the core of all decision making.

Step 1: Assess and/or Reassess

Discussion: A comprehensive patient assessment is essential to identify factors that may impact skin integrity and wound healing and should include: history and current health status (physical, emotional), head-to-toe skin assessment and wound assessment (if applicable). This also includes investigation of environmental factors such as socio-economic, cultural, health literacy, care setting, access to services (travel costs, web-based, and hybrid), and system factors such as diabetes-related policies, resources and programs.[25]

During the assessment phase, the clinician should obtain a medication list and identify medications that may interfere with skin health or wound healing (e.g., anticoagulants, nicotine, corticosteroids, immunosuppressants, non-steroidal anti-inflammatories, immunomodulators [e.g., infliximab, etanercept], tumor necrosis factors - TNF], colchicine, and chemotherapeutic agents).[26,27] In addition, clinicians should assess patients' risk of DM-related distress, depression, anxiety, and care adherence, as this may provide a more realistic care plan.[28,29]

Recommendations

1.1 Select and use validated screening and risk assessment tools

The use of validated and standardized patient and risk assessment tools is essential for identifying factors that may cause skin breakdown, impede healing and affect quality of life of individuals at risk for, or with, diabetic foot complications. They also provide direction for establishing a plan of care and carrying out preventative skin and foot care or foot complication management.

Discussion:

Foot-Risk Screening Tools

Clinicians should use validated foot screening tools in practice. Foot screening can be completed by trained primary care providers such as a nurse practitioner, family physician, podiatrist/chiropodist, foot care nurse, diabetes nurse, registered dietitian, physiotherapist or occupational therapist. Foot screening tools provide a uniform approach that helps ensure that a comprehensive foot exam is completed and that the results are clearly communicated to the patient and the integrated team.[1] There are several validated tools for clinicians to consider for use in their practice.[30,31] A risk screening tool is most effective when clinicians receive regular education and training and when organization and system supports (policies and procedures) are in place to communicate findings and to initiate timely interdisciplinary team referrals.[17] In this chapter we discuss Inlow's 60-second Diabetic Foot Screen: Update 2022.[32]

Patient Quality-of-life Screening Tools/Scales

Persons with diabetes are at risk of experiencing diabetes distress and depressive disorders.[33] The prevalence of depressive disorders in persons with diabetes is approximately 10% to 15%, twice as high as the prevalence of depression in persons without diabetes.[34] As well, individuals with diabetes may experience social changes in areas such as employment, driving, schooling, family role and responsibilities, and coping abilities.

Patient Quality-of-Life Screening Tools (See Appendix A)

- The Problem Areas in Diabetes Scale (PAID)[35]
- The Diabetes Distress Screening Scale[36,37]
- The World Health Organization – WHO-5 Well-being Index[38]
- The Hospital Anxiety and Depression Scale (HADS)[39]
- The Patient Health Questionnaire (PHQ-9)[40]
- The Center for Epidemiological Studies-Depression Scale (CES-D)[41]
- The Beck Depression Inventory[42]

Care partners' quality of life and stress

The care partners of the person with diabetes and/or with a foot ulcer is key to supporting the patient's care, short and long term.[13] Care partners may also experience feelings of stress and distress surrounding their diabetes-related caregiving activities.

Care Partner Stress Screening Tools (See Appendix B)

- Kingston Caregiver Stress Scale (KCSS)[43] Available at https://providencecare.ca/wp-content/uploads/2016/10/KCSS-Assessment-Form.pdf
- The University of Washington Center on Outcomes Research in Rehabilitation has developed several self-reported measures for consideration.[44]
  Available from: https://uwcorr.washington.edu/measures/
  · University of Washington Caregiver Stress Scale
  · University of Washington Caregiver Benefit Scale
  · University of Washington Self Efficacy Scale (UW-SES)
- The Behavioral Diabetes Institute offers tools for caregivers of teens, adults and partners of adults with diabetes.[45]
  Available from: https://behavioraldiabetes.org/scales-and-measures/

Quality of Life for Persons Undergoing Amputation

- The Trinity Amputation and Prosthesis Experience Scale (TAPES-R) – Revised[46]
- Amputee Mobility Predictor Assessment Tool – AMPnoPRO[47]
- Functional Assessment Questionnaire for Amputees (FMA)[48]

Quality-of-Life Tools and Scales for Persons Experiencing an Amputation and/or Prosthesis (See Appendix C)

1.2 Identify risk and causative factors that may impact skin health, skin integrity and wound healing

Discussion: Individuals with diabetes may have modifiable and/or non-modifiable risk factors[1,49] that can impact skin integrity and wound healing.[1] Prevention of foot complications is the cornerstone to improving patient outcomes, especially as diabetes rates continue to rise in Canada.[2]

The IWGDF (2023) guidelines outline five essential elements to identify risk and prevent diabetes-related foot ulcers, especially for patients without a current foot ulcer.

- First, it is essential to identify individuals with an 'at-risk foot' *before* complications arise. This involves assessing risk factors such as neuropathy, peripheral arterial disease and foot deformities. This includes the patient's ability to engage in self care activities.
- Second, regular examination of the feet in at-risk individuals is key for early detection of potential issues that could lead to ulceration.
- Third, structured, repeated education is emphasized, targeting patients, their care partners, family members and health-care professionals. Education focuses on raising awareness about diabetic foot risks, self-management, mental health, preventative care and the importance of early intervention.

- Fourth is the critical element of providing recommendations to patients about accessing and wearing appropriate footwear (seasonal). They should also be dissuaded from soaking their feet, as it causes maceration. Footwear protects feet (skin/nails), reduces pressure points and prevents injuries that could lead to pre-ulceration/ulceration.
- Finally, addressing risk factors for ulceration, such as blood glucose levels, skin and nail care, biomechanical abnormalities and footwear issues, forms a critical part of the prevention strategy. These combined efforts aim to significantly reduce the risk of foot ulceration in individuals with diabetes, thereby improving their overall health outcomes.[1]

See below the list of modifiable and non-modifiable risk factors the clinician might identify during the patient assessment.

Modifiable Risk Factors

- Glycemic level: hyperglycemia results in delayed wound healing and compromised chemotaxis and phagocytosis[50,51]
- Activity: patients may participate in activities that are not appropriate for their risk levels (e.g., running) because they can lead to injury and interfere with wound healing[52,53] Patients with an active ulcer should exercise under direction of health-care professionals
- Smoking/vaping compromises blood flow, increasing the risk of wounds and delaying healing
- Trauma: patients with diabetic neuropathy and loss of protective sensation (LOPS) are prone to injury/re-injury
- Footwear: ill-fitting and inappropriate footwear pressure increases the risk of skin breakdown and may interfere with healing
- Neuropathy: manifested in the sensory, autonomic and motor (SAM) components of the nervous system. Once neuropathy is established, it is not reversible and exacerbates the development of ulcerations, pain and poorer quality of life
- Bony deformity can result in areas of high pressure and skin breakdown
- Peripheral arterial disease increases the risk for the development of ulcers and impacts wound healing
- History of ulcers: healed wounds are more vulnerable to re-injury due to less resiliency and elasticity
- Amputation: abnormal biomechanics post partial foot amputation may lead to poor wound closure and/or new pressure injuries. Ill-fitting prosthetics may cause wounds on residual limbs from pressure or friction
- Vision changes such as retinopathy, cataracts, glaucoma and macular edema that change vision and may lead to blindness[54]
- Sleep patterns are affected by diabetes and thereby affect blood glucose control and quality of life[55]
- Increased body mass index (BMI) overweight or obesity (weight in the mid-girth area) may occur in relation to insulin and antihyperglycemic medication, increasing risk of complications. Managing weight is important.[56]

Non-Modifiable Risk Factors

- Gender
- Age
- Family history of diabetes, foot complications and amputation
- Ethnicity

Patient Quality of Life Screening

It is important to screen early in the assessment for a persons' risk of diabetes distress, depression and anxiety using reliable and validated tools that are diabetes-specific and measure quality of life.[28] Tegegne et al. report the prevalence of depression to be substantial, especially if the patient is older, not participating in formal education, living longer with diabetes and experiencing lower participation in diabetes self-management.[59] See Appendix A: Patient Quality-of-Life Screening Tools.

The importance of screening for risk of underlying mental health issues, in turn, supports patients and care partners to fully engage in preventive self-care and education.[28,60,61] Patients live with significant diabetes-related responsibilities. These multi-facted activities include daily monitoring requirements related to blood glucose and blood pressure management, medications, nutrition, activity, emotional balance, footwear/foot health and co-ordinating appointments and diagnostic tests. It is, therefore, important that mental health screening be completed regularly, and referrals and appropriate services be offered throughout a patient's care continuum.

Care Partner Quality-of-life

Clinicians are responsible for referring the care partner for support or to screen using credible tools.[43] Care partners of patients living with diabetes are at risk of burnout. See Appendix B: Care Partner Stress Screening Tools.

Quality of Life for Persons Undergoing Amputation and/or Prosthesis

For patients who undergo foot surgery and/or amputation (minor or major), their mental health and well-being should continue to be assessed at regular intervals.[62,63] After surgery many patients undergo further changes to their employment, mobility, self-esteem, body image and ability to cope.[64] See Appendix C: Quality-of-Life Tools and Scales for Persons Experiencing an Amputation and/or Prosthesis.

Foot Screening

The IWGDF recommends annual screenings for individuals with diabetes who are considered to be at very low risk of foot ulceration (IWGDF risk 0) with the goal of detecting potential risk factors for ulceration. Despite the absence of symptoms, people with diabetes can still suffer from foot diseases, such as asymptomatic neuropathy, PAD, pre-ulcerative signs or ulcers. Yearly foot exams confirms the level of risk.[1]

Assess for loss of protective sensation (LOPS) using techniques such as the Semmes-Weinstein 10 gram monofilament, a 128 Hz tuning fork, or tactile sensation tests when the above-mentioned tools are unavailable. Screening includes evaluating the vascular status by checking for symptoms of intermittent claudication (IC) and palpating pedal pulses. Identifying LOPS or PAD during these screenings indicates an increased risk of ulceration, necessitating further examination and interdisciplinary referrals.[1]

A consistent, uniform approach to diabetic foot risk screening ensures that all elements of the examination are completed. Risk factor recognition is vital in helping clinicians predict and prevent the occurrence of diabetic foot ulcers.[65] The most effective method for amputation prevention may simply be to have all health-care professionals teach patients to remove the shoes and socks and examine their feet and footwear.[66]

Risk Stratification

Inlow's 60-second Diabetic Foot Screen Risk Screening (2022) and Plan of Care tool aligns with the IWGDF risk stratification recommendations. This includes recommendations, actions and associated education with patients and care partners in efforts to support prevention and engagement in planning proactive, preventative care. To conduct the foot screen, work with the patient to complete the three steps. Remember this is an opportunity to build a trust-filled therapeutic relationship with the patient and care partner(s).

Inlow's 60-second Diabetic Foot Screen: Update 2022

- In **Step 1,** ask the patient (care partner(s)/family) about self-reported risk factors/comorbidities such as: retinopathy (vision), nephropathy (renal), poor glycemic control, cardiovascular disease, PAD and history of smoking.
- In **Step 2,** determine the risk for ulcerations and amputations using categories: Very low risk – category 0; Low risk – category 1; Moderate risk – category 2; High risk – category 3; Urgent risk.
- In **Step 3,** co-create a plan of care with the patient and/or care partner. The findings of the foot screen direct the care plan, frequency of future foot screening, prevention, patient-centred education and actions and referrals to be made to the interdisciplinary team members (See Figure 2: Inlow's 60-second Diabetic Foot Screen).

Figure 2: Inlow's 60-second Diabetic Foot Screen

Inlow's 60-second Diabetic Foot Screen

2022 RISK SCREENING AND PLAN OF CARE

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Patient Name: **Clinician Signature:**

ID number: **Date:**

▶ Step 1: Complete Screen of the Right and Left Feet

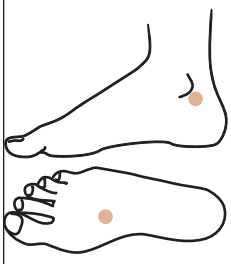
Instructions: Screen both feet using the parameters identified within Inlow's 60-second Diabetic Foot Screen[1] to identify clinical indicators and/or care concerns. Once each parameter has been assessed move on to Steps 2 and 3.

Self-Reported Risk Factors/Comorbidities

☐ Retinopathy ☐ Nephropathy ☐ Poor glycemic control ☐ Cardiovascular disease ☐ Peripheral Arterial Disease ☐ Smoking

RIGHT FOOT	1. Screen for Foot Skin and Nail Changes	LEFT FOOT	Risk Status and Care Planning
	**Skin:** ☐ Intact and healthy ☐ Dry with fungus or light callus ☐ Heavy callus build up ☐ Prior ulceration ☐ Existing ulceration (± warmth and erythema) ☐ Macerated web space **Nails:** ☐ Well-groomed and appropriate length ☐ Unkempt and ragged ☐ Thick, damaged, or infected		

RIGHT FOOT	2. Screen for Loss of Protective Sensation	LEFT FOOT	Risk Status and Care Planning
	**Foot Sensation – do they ever:** ☐ • feel numb? ☐ • tingle? ☐ • burn? ☐ • feel like insects are crawling on them? **Foot Sensation – monofilament testing:** ☐ No: Loss of protective sensation was not detected (sensation was present at all sites) ☐ Yes: Loss of protective sensation detected (sensation was missing at one or more sites)		

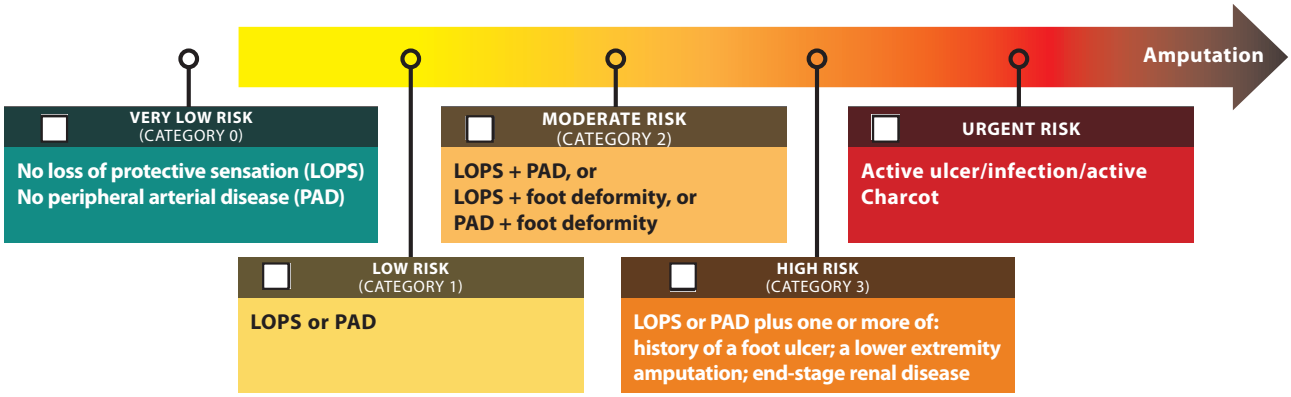
RIGHT FOOT	3. Screen for Peripheral Arterial Disease	LEFT FOOT	Risk Status and Care Planning
	**Pain:** ☐ Pain in the feet or legs when walking, limiting mobility **Dependent rubor:** ☐ No ☐ Yes **Cool foot:** ☐ No ☐ Yes **Pedal Pulses:** ☐ Present ☐ Absent		

RIGHT FOOT	4. Screen for Bony Deformity (and Footwear)	LEFT FOOT	Risk Status and Care Planning
	**Deformity:** ☐ No deformity ☐ Deformity (i.e. dropped metatarsal heads or bunion, chronic Charcot changes, hammertoes) ☐ Prior lower extremity amputation ☐ Acute Charcot (+ warmth and erythema) **Range of Motion:** ☐ Full range in hallux ☐ Limited range of motion in hallux ☐ Rigid hallux **Footwear:** ☐ Appropriate ☐ Inappropriate ☐ Causing trauma		

* Refer to Steps 2 and 3 before completing this area.

▶ Step 2: Determine the Risk for Ulceration and Amputation

Instructions: Review the results from Inlow's 60-second Diabetic Foot Screen to identify parameters that put the patient at risk. *Very low risk involves no loss of protective sensation, peripheral arterial disease or related comobidities/risk factors. If comorbidities exist, consider increasing to Category 1.



▶ Step 3: Create a Plan of Care with Your Patient Based on Identified Risks

Instructions: Based on the risk classification and clinical indicators develop a plan of care with your patient that best meets their needs.

Risk Category	Clinical Indicators	Screening Frequency	Recommendations and Actions**
Very Low Risk (Category 0)	No loss of protective sensation (LOPS) and no peripheral arterial disease (PAD)	Screen every 12 months	☐ Education on: risk factors; daily foot inspection; appropriate footwear and foot- and nail-care;† when/how to seek medical attention if needed ☐ Daily inspection of feet ☐ Appropriate foot and nail care ☐ Well-fitting footwear ☐ Exercise as able
Low Risk (Category 1)	LOPS or PAD	Screen every 6–12 months	☐ Education on: risk factors (including LOPS or PAD); daily foot inspection; appropriate footwear and foot- and nail-care; when/how to seek medical attention if needed ☐ Daily inspection of feet ☐ Professional foot and nail care, including treatment of onychomycosis and Tinea pedis if present ☐ Well-fitting, sensible footwear with custom, full-contact foot orthoses and diabetic socks ☐ Vascular studies ± referral to a vascular investigation +/- vascular surgeon ☐ Pain management for ischemic pain, if present ☐ Recommend non-weight bearing exercise program https://www.diabetes.ca/nutrition---fitness/exercise---activity
Moderate Risk (Category 2)	LOPS + PAD, or LOPS + foot deformity, or PAD + foot deformity	Screen every 3–6 months	☐ Education on: risk factors (including LOPS ± PAD ± foot deformity); daily foot inspection; appropriate footwear and foot- and nail-care; when/how to seek medical attention if needed ☐ Daily inspection of feet ☐ Professional foot and nail care, treatment of onychomycosis and Tinea pedis if present ☐ Well-fitting, orthopaedic footwear with custom full-contact total contact casted foot orthoses and diabetic socks. Footwear must accommodate any deformities present ☐ Vascular studies ± referral to a vascular surgeon ☐ Pain management for ischemic or neuropathic pain ☐ Referral to a general, orthopedic or foot surgeon, if indicated, surgically manage foot deformities ☐ Recommend non-weight bearing exercise program https://www.diabetes.ca/nutrition---fitness/exercise---activity
High Risk (Category 3)	LOPS or PAD plus one or more of: • history of a foot ulcer • a lower extremity amputation • end-stage renal disease	Screen every 1–3 months	☐ Education on: risk factors (including LOPS ± PAD ± foot deformity); risk of ulcer recurrence; daily foot inspection; appropriate footwear and foot- and nail-care; when/how to seek medical attention if needed ☐ Daily inspection of feet ☐ Professional foot and nail care, including treatment of onymycosis and Tinea pedis, if present ☐ Well-fitting, orthopedic footwear with custom full-contact total contact casted foot orthoses and diabetic socks. Footwear must accommodate any deformities present ☐ Modified footwear and/or prosthesis based on level of amputation ☐ Vascular studies ± referral to a vascular surgeon ☐ Pain management for ischemic or neuropathic pain ☐ Recommend non-weight bearing exercise program https://www.diabetes.ca/nutrition---fitness/exercise---activity
Urgent Risk	Active ulcer/infection/ active Charcot	Urgent care required	☐ Education on: signs of wound infection and wound care; risk factors (LOPS ± PAD ± foot deformity); risk of ulcer recurrence; daily foot inspection; appropriate footwear and foot- and nail-care; when/how to seek medical attention ☐ Daily inspection of feet ☐ Professional foot and nail care, including treatment of onymycosis and Tinea pedis, if present ☐ Offloading with total contact cast, removable cast walker or wound shoe to close ulcers and/or to immobilize Charcot foot ☐ Vascular studies ± referral to vascular surgeon or limb preservation clinic, as indicated ☐ Pain management for ischemic pain or neuropathic pain ☐ Referral to a general, orthopedic or foot surgeon, if indicated, to surgically manage foot deformities ☐ Referral to infectious diseases to manage infection, if indicated, and/or to a general, orthopedic or foot surgeon to debride infectious tissue ± bone, if indicated

** These recommendations and actions are not all-inclusive. Actions need to be customized to meet each patient's needs. Encourage patients (and caregivers) to manage their glycemic levels, triglycerides, weight, hypertension, and lifestyle choices such as smoking. Ensure the patient knows where to access professional assistance in the event of an urgent foot complication.

† Tools and educational materials are available online from Wounds Canada:
For patients (and caregivers): https://dhfy.ca/for-patients-public
For clinicians: https://dhfy.ca/for-clinicians

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Assessing the Pathophysiology of the Diabetic Foot

Understanding the pathophysiology of diabetes is very important as it represents an awareness of the physiology of altered health. Pathophysiology deals with the structural and functional changes in the patient's cells, tissues and organs caused by diabetes.[67] The pathophysiology of diabetic foot complications is directly linked to amputation risk. Key factors contribute to this risk:

- Peripheral neuropathy (sensory, autonomic, motor) reduces protective foot sensation
- Peripheral arterial disease (PAD) and vascular problems hinder wound healing
- Foot and bony changes affect footwear fit and, along with neuropathy, lead to trauma. Unnoticed, untreated wounds may become infected, further weakened by impaired blood flow, ultimately causing tissue damage, infection, gangrene and, in severe cases, a necessity to amputate to prevent infection spread, other complications and death.[17] See **BOX** on Pathophysiology under Recommendation 1.2.

As mentioned in the introduction, understanding pathophysiology of the diabetic foot is critical for understanding patient risk, prevention of complications, treatment and management of lower limb/foot complications. Persons with diabetes (up to 25%) are at greater risk of developing foot ulcerations (wounds) in their lifetime. Ulcers lead to infection in the tissues, bone, tendon, and may lead to amputation (minor, major) and death. Therefore, understanding the pathophysiology of the disease is crucial to assessment approaches, diagnosis and treatment options. The components to consider in the development of a diabetic foot ulcer are as follows.

1. Peripheral neuropathy, to which persons with diabetes are prone, affects sensory, motor and autonomic nerves. Diabetic peripheral neuropathy may be asymptomatic in up to 50% of patients.[68] Diabetic sensory neuropathy classically presents as a distal symmetric sensorimotor neuropathy and is the leading cause of foot ulcers.[69] Other causes of neuropathy should be considered in patients with diabetes, as they may be treatable. Other causes of neuropathy to consider would be toxins (e.g., alcohol use, chemotherapy agents), vitamin B12 deficiency, hypothyroidism, renal disease, malignancy (e.g., multiple myeloma, bronchogenic carcinoma), infections (e.g., HIV), vasculitis and chronic demyelinating neuropathy.[70]

Sensory neuropathy relates to loss of protective sensation due to small and large fibre nerve changes. Large fibre function can be evaluated using the monofilament test (MFT), vibration perception or lower extremity reflexes. Evaluation of small fibres can be tested using pin prick or temperature. Early symptoms of neuropathy are described as burning or tingling as a result of small fibre changes. Loss of large fibres results in loss of protective sensation, and patients will often report numbness.[70]

Autonomic neuropathy in the foot leads to skin atrophy, dry or overly moist skin and brittle toenails. Skin changes due to autonomic neuropathy need to be distinguished from fungal infections.[70]

Motor neuropathy is characterized by intrinsic muscle atrophy and results in contracted digits and a displaced fat pad from the metatarsal heads to just below the toes. Consequently, metatarsal heads become prominent and close to the skin surface, leading to increased pressure and a potential ulceration site. Abnormal pressure over bony deformities can lead to callus formation and ulceration, particularly in the absence of protective sensation. A body of evidence has shown that elevated plantar pressure is a major risk factor for ulcer development. There is a direct relationship between elevated pressures and deformity.[70]

2. Peripheral artery disease (PAD) is present in about 50% of patients with diabetes and typically affects the distal lower limb. PAD is four times more common in people with diabetes than in those without diabetes.[71] Pain may be present in a small percentage of those with no neuropathy but significantly reduced blood flow to the extremity. The symptom of pain in patients with diabetes may be unreliable due to the presence of neuropathy. Pain with arterial claudication is described in a specific area of the lower limb that is brought on by exercise and relieved by rest. This nociceptive pain signal is often described as gnawing, aching, tender or throbbing (GATT). The location of the discomfort can be anywhere from the buttock to the calf, depending on where the blockage of blood flow occurs. More concerning is critical limb threatening ischemia (CLTI), defined as ischemic rest pain, tissue loss or gangrene that is present for a minimum of two weeks.[72] This should prompt an urgent vascular consultation. Risk factors for PAD are similar to other atherosclerotic vascular diseases; however previous cardiovascular history, diabetes, smoking and age are the strongest factors.[73] The impact of smoking on PAD is stronger than for coronary artery disease.[74] See PAD campaign Wounds Canada.

Figure 3: Peripheral Artery Disease – Wounds Canada

Source: https://www.woundscanada.ca/patient-or-caregiver/preventing-and-managing-wounds/293-patient-caregiver/wound-index/573-peripheral-arterial-disease

3. Foot deformity Foot deformity is a pivotal risk factor in the onset of diabetic foot ulcers (DFUs) and has been highlighted by the American Diabetes Association's Foot Care Interest Group as part of a critical triad alongside neuropathy and trauma.[75] This triad synergistically leads to ulceration, with deformities such as interphalangeal and metatarsophalangeal joint (MTPJ) deformities, pes cavus and pes equinus being particularly significant. MTPJ deformities, including hammer-and-claw toes and hallux valgus, are the most common in persons with diabetes.

The development of these foot deformities is linked to motor neuropathy, which causes muscle atrophy, reduced joint mobility and uneven pressure distribution on the foot. This leads to a degradation of musculoskeletal integrity, notably atrophy of foot muscles and fatty infiltration, undermining joint stability and foot functionality. As a result, there's an alteration in foot structure and mechanics, such as MTPJ hyperextension and hyper curvature of interphalangeal joints, which increase pressure on the metatarsal head and promote tissue damage through repetitive stress and ischemia-reperfusion injury.[76] See Figure 4 for how to examine for foot deformities in a person with diabetes.

Figure 4: How to Examine Foot Deformities in a Person with Diabetes

In a person with diabetes with LOPS or PAD (IWGDF risk 1–2), perform a comprehensive foot deformity examination:

A	B	C	D	E
Hallux abductus valgus	**Hammer toe**	**Claw toe**	**Metatarsal head prominence**	**Charcot-foot deformity**
				
Definition: lateral deviation from normal shape of the 1st MPJ	**Definition:** flexion contracture of the proximal IPJ and neutral flexion contracture of the distal IPJ (e.g., 2nd and 3rd toes)	**Definition:** plantar flexion of the proximal and distal IPJs and dorsiflexion of the MPJ (e.g., 2nd and 3rd toes)	**Definition:** bony prominence located beneath a metatarsal head (e.g., 3rd head)	**Definition:** mid-foot Charcot rocker-bottom deformity

IWGDF Definitions:
- **LOPS:** loss of protective sensation
- **PAD:** peripheral artery disease
- **MPJ:** metatarsophalangeal joint
- **IPJ:** interphalangeal joint

Permission granted by D-Foot International.

In addition, hyperkeratosis (thickening and darkening of the skin) and pathological tendon changes exacerbate plantar pressure, restrict joint movement, and diminish ankle dorsiflexion, further heightening the risk of DFU development. Trauma can take many forms, but often is a result of repetitive impact causing callus formation, pressure from ill-fitting shoes, acute changes from sharp objects, blunt trauma or thermal injury.

Integrated teams should adopt *The Foot Health Pathway for People with Diabetes*.[17] Also, they should utilize a comprehensive approach to classify diabetic foot conditions, aimed at consistent, clear communication of findings among the team. The IWGDF recommends using the six items SINBAD (Site, Ischemia, Neuropathy, Bacterial infection, Area, and Depth) to classify the foot ulcer. This system requires detailed description of each variable rather than relying on a total score. An alternative is the WIfI (Wound, Ischemia, and foot Infection) system, recommended when the necessary equipment and expertise are available and feasible. These are discussed further in this document (IWGDF, 2023). Finally, the International Wound Infection Institute[77] discusses nine additional wound infection assessment tools in Wound Infection in Clinical Practice.

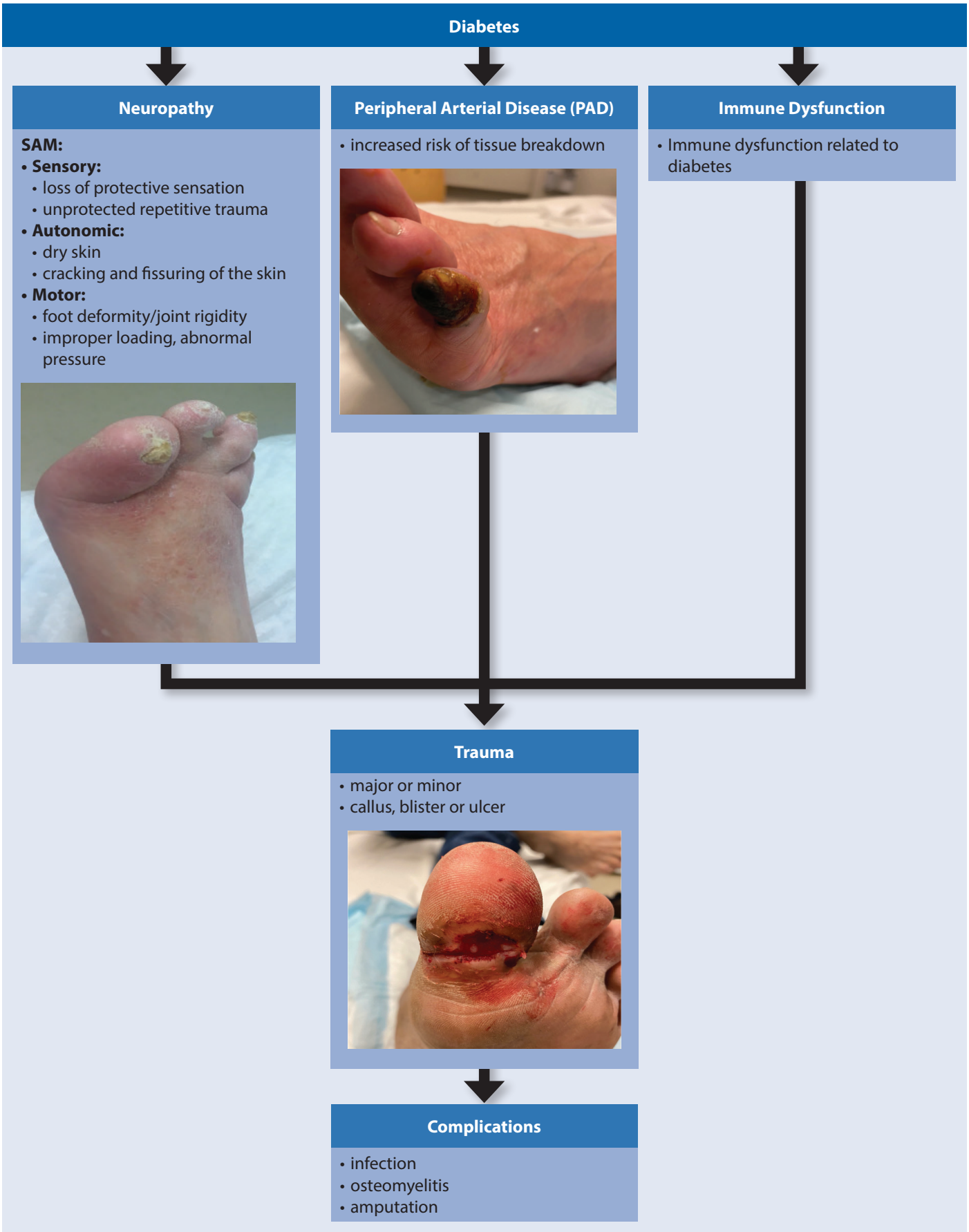
Pulling It Together: Identifying risk factors alongside the comprehensive patient assessment must be examined together to understand the health of the person's lower limbs/feet. Understanding the pathophysiology (peripheral neuropathy, arterial disease and foot deformity) blood glucose levels, hemoglobin A1c, history, lifestyle and footwear help create a focused assessment.

Diabetic foot infections remain the most frequent complication of diabetes requiring hospitalization and are the most common precipitating events for lower leg amputation(s).[1] Any form of trauma to the insensate foot (e.g., a sharp blow, thermal injury, pressure or friction) can result in disruption of the skin barrier and penetration of bacteria. The underlying immune disturbance and perfusion issues that are common in persons with diabetes allow for the inflammatory reaction to progress to infection. See Table 2 for an overview of factors that lead to neuropathy, the at-risk foot, foot ulcers, infections and amputations.

Table 2: Risk Factors for Neuropathy, at Risk Foot; Foot Ulcers, Infection and Amputation (Adapted from:[1,28,70,78,79])

Neuropathy	At-risk foot	Foot Ulcers	Infections	Amputation
Elevated blood glucose (and duration of diabetes)	Poor glycemic management	Peripheral neuropathy	Vascular complications	DFU patients, including the male sex
Elevated triglyceride (should be dyslipidemia)	Peripheral neuropathy/LOPS	Previous ulceration or amputation	Retinopathy	Smoking history
Body mass index (BMI) overweight, obese	PAD	Structural deformity	Number of ulcers, osteomyelitis	History of foot ulcers
Smoking	Foot deformities (bunions, hammertoes, Charcot joint, etc.)	Limited joint mobility	Diabetic nephropathy	Osteomyelitis, gangrene
Hypertension	Pre-ulcerative corns or calluses	PAD	Elevated HbA1c levels	Lower body mass index
	Prior ulceration	Onychomycosis	Higher Wagner grades	Higher white blood cell count (WBC)
	Prior amputation	High glycated hemoglobin (HbA1c) levels		
	Smoking			
	Retinopathy			
	Nephropathy (particularly in individuals on dialysis or posttransplant)			

Figure 5: Pathophysiology



Permission granted by Dr. Robyn Evans.

1.2.1 Patient: Physical, emotional and lifestyle

Discussion

Physical Assessment

A complete patient medical history is essential as it identifies undisclosed medical conditions or potential risks for wound development, delayed wound healing and risk for peripheral artery disease. A complete history should elicit any active and past medical conditions. The complications of diabetes include retinopathy, neuropathy, vasculopathy and mental health concerns. It is important to obtain a smoking history (all substances), as this represents a major risk for development of peripheral arterial disease (PAD). A patient's history may also identify barriers to self-management, care partner support and clinician-delivered care. This may include visual or auditory impairments and culture/language challenges that may prevent a patient or care partner from conducting preventative and effective foot assessments or receiving foot health instructions. By recognizing barriers early, patients and their team can co-create informed and effective plans of care.

HbA1C: This blood test reflects glycemic levels over the past three months and is critical in managing diabetes, preventing complications, and in wound healing. It is a convenient test as it can be measured any time of the day and helps predict microvascular complications.[28] Elevated HbA1c levels are linked to an increased risk of microvascular and macrovascular complications, such as cardiovascular disease, retinopathy and neuropathy. Clinical trials have shown that intensive glucose-lowering therapy reduces the incidence of these complications, with every one percent reduction in HbA1c translating to better health outcomes.[80] Clinicians will determine the most appropriate range of glycemic control for each person based on a full assessment (See Figure 6: Glycemic control: Targets for People with Diabetes).

Figure 6: Glycemic Control: Targets for People with Diabetes

Target	
<6.5%	To reduce risks of microvascular disease
<7.0%	Most adults with DM
7.1–8.5%	Frail elderly, functionally dependent, recurrent/severe risk of hypoglycemia

Clinicians can support patients by using the online calculator to individualize your patient's A1c target. (Diabetes Canada, 2024 February 1). https://www.diabetes.ca/managing-my-diabetes/tools---resources/individualizing-your-patient%E2%80%99s-a1c-target

Vascular Status: Peripheral Arterial Disease

For clinical assessment of individuals with diabetes, with or without foot ulcers, evaluating for PAD is critical.[1] A comprehensive examination should include a focused vascular history and physical examination, specifically by palpating pulses (femoral, popliteal, dorsalis pedis and posterior tibial) and noting signs of vascular compromise such as hair loss, nail thickening, delayed capillary refill and temperature differences.[1]

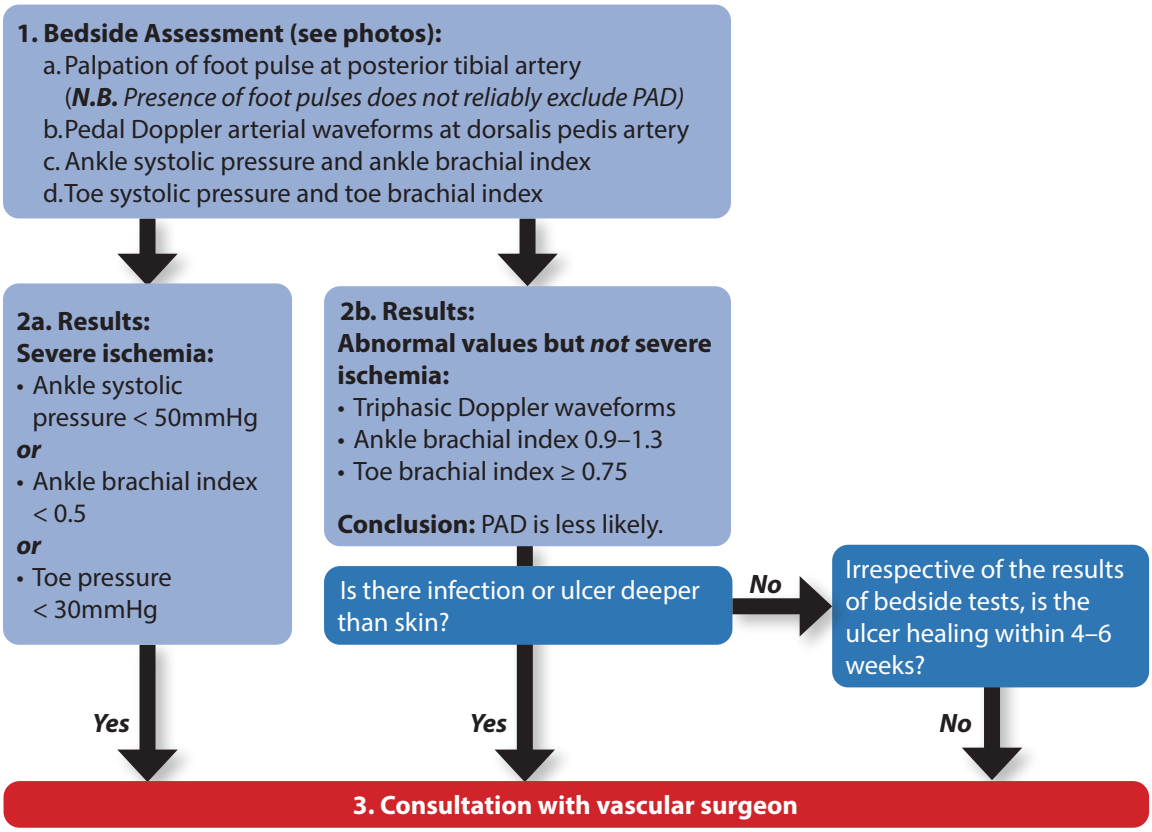
This approach highlights the critical role of specific diagnostic measures in managing the complex interplay between diabetes, foot health, foot ulcers and PAD. For individuals presenting with a foot ulcer and PAD, relying solely on signs and symptoms for ulcer healing prediction is deemed unreliable. Instead, the IWGDF recommends employing one of the following diagnostic tests to aid prognosis:

- a skin perfusion pressure of at least 40 mmHg
- a toe pressure of at least 30 mmHg
- a transcutaneous oxygen level ($TcPO_2$) of at least 25 mmHg, albeit other sources suggest a $TcPO_2$ threshold of55 mmHg for prognosis.[1]

Characteristics of the ulcer are also important; distal, punched-out ulcers with a pale base may indicate vascular compromise. Distal gangrene of the toes with a palpable pulse or adequate circulation

may indicate micro-emboli from proximal atheromatous plaques. Abnormal physical findings need to be confirmed with further diagnostic test.[81]

Figure 7: How to Perform a Vascular Assessment in a Person with Diabetes and a Foot Ulcer



a. Palpation of foot pulse at posterior tibial artery

b. Pedal Doppler arterial waveforms at dorsalis pedis artery

c. Ankle systolic pressure and ankle brachial index

d. Toe systolic pressure and toe brachial index

Note: Assess for claudication and critical limb ischemia
Permission granted by D-Foot International.

For patients with diabetes, especially those with neuropathy, traditional signs of PAD may be absent or misleading, and the ankle-brachial pressure index (ABPI) might be inaccurately high due to arterial calcification.[82] Alternatives such as toe pressures and transcutaneous oxygen measurements are recommended for more accurate blood flow assessment.[1,25] Diagnosis of PAD may also utilize audible hand-held Doppler devices, with further confirmation by duplex Doppler in vascular labs if necessary.[83] There is no single modality that can reliably exclude PAD. The values listed in Table 3 indicating a normal ABPI, TBPI and triphasic/biphasic waves make PAD less likely. However, if an ulcer is present and not healing as expected, further evaluation with referral to a vascular surgeon should be considered. The presence of infection should also prompt a more urgent referral.

Table 3: Assessing Arterial Flow and Perfusion

Grade	Ankle-Brachial Pressure Index (ABPI)	Toe Brachial Pressure Index (TBPI)	Toe Pressure	Waveforms	Transcutaneous Oxygen Pressure ($TcPO_2$) - indicates perfusion
Non compressible	>1.40 Be aware of possible falsely elevated measures	Preferred when vessels are non-compressible	Preferred when vessels are non-compressible		Preferred when vessels are non-compressible or when localized perfusion may be altered due to previous insult (trauma or surgical repair)
Normal range	1.0–1.40	>0.7	>70 mmHg	Triphasic	>40 mmHg
Borderline	0.91–0.99	>0.6	>70 mmHg	Biphasic/ monophasic	>40 mmHg
Abnormal	<0.90	<0.6	<70 mmHg	Biphasic/ monophasic	<40 mmHg
Mild	0.7–0.9	>0.4	>50 mmHg	Biphasic/ monophasic	30–39 mmHg
Moderate	0.41–0.69	>0.2	>30 mmHg	Biphasic/ monophasic	20–29 mmHg
Severe	< 0.4 critical limb threatening ischemia (CLTI)	<0.2	<30 mmHg	Monophasic	<20 mmHg

The IWGDF emphasizes the significance of limb ischemia in foot ulcer healing rates and recommends cardiovascular risk reduction, potential pharmacological interventions for perfusion enhancement and consideration for revascularization based on specific diagnostic thresholds. Urgent vascular imaging and revascularization may be necessary for severe cases to improve healing prospects.[1]

Sensation

Patients with type 2 diabetes should undergo yearly diabetic peripheral neuropathy (DPN) screening at diagnosis, and those with type 1 diabetes should be evaluated five years after diagnosis, with yearly assessments following. These evaluations should include a detailed medical history, tests for small fibre (temperature or pinprick sensation) and large fibre (vibration sensation using a 128-Hz tuning fork) functions, and annual 10-g monofilament testing to check for LOPS. While up to half of diabetic neuropathies may be asymptomatic, emphasizing the importance of preventative care, current treatments focus on glycemic control rather than direct nerve repair. Regular assessments for DPN aim to manage symptoms early and improve quality of life, incorporating specific tests for both small and large fibre function, with electrophysiological tests or neurology referrals being exceptional measures.[70] Figure 8 demonstrates how to perform a sensory foot examination.

Figure 8: How to Perform a Sensory Foot Examination

1 10-g (5.07) Semmes-Weinstein monofilament

The test:
- Test for presence or absence of protective sensation
- Repeat this application twice at the same site but alternate this with at least one "mock" application in which no filament is applied (conduct a total of three questions per site).

Method:
- Apply perpendicular to the skin surface with sufficient force to cause the filament to bend or buckle
- Hold approximately 2 seconds
- Time necessary to perform this examination: 2 min for both feet
- Test these three sites:

Hallux

1st metatarsal head

5th metatarsal head

Results:
- Ask the patient if they feel the pressure:

Yes:
- Pressure sensation *present* at each site
- Two out of three answers are *correct*

No:
- Pressure sensation *absent* at each site; *OR*
- Two out of three answers are *incorrect*; *OR*
- Results *ambiguous*

No

2 128 Hz Tuning Fork

The test:
- Test for presence or absence of vibratory sensation
- Repeat this application twice at the same site but alternate this with at least one "mock" application in which the tuning fork is not vibrating.

Method:
- Time necessary to perform this examination: 3 to 5 min. for both feet
- Test on hallux; use another toe if hallux is absent

Dorsal hallux (distal phalanx)

Results:
- Ask the patient if they feel the vibration:

Yes:
- Vibration sensation *present* at each site
- Two out of three answers are *correct*

No:
- Vibration sensation *absent*
- Two out of three answers are *incorrect*

No

3 Ipswich Touch test

The test:
- Test for presence or absence of light touch sensation

Method:
- When touching do not push, tap or poke; touch lightly
- Hold 1 to 2 seconds
- Time necessary to perform this examination: 2 min. for both feet
- Test these three sites:

Hallux

3rd toe

5th toe

Results:
- Ask the patient if they feel the light touch:

Yes:
- Light touch sensation *present* at 2 or more sites

No:
- Light touch sensation *absent* at 2 or more sites

Permission granted by D-Foot International.

For additional information and steps to conducting sensation tests see Appendix D: Additional Information on Conducting Sensation Tests. Refer to this for details on using:

- The 10-gram monofilament sensation test
- The Ipswich Light Touch test
- The 128 Hz tuning fork.

Bony Structural Deformities

Foot deformities in patients with diabetes can result from neuropathic changes, stiffening of the joints (cheiroarthropathy) altered biomechanics, or previous surgeries.[84]

For a detailed discussion of Charcot foot see Appendix E: Charcot Neuro-osteoarthropathy (CNO or Charcot Foot).

The ability of the first toe joint to dorsiflex (lift upward) is essential to normal foot function. Limitation in the range of motion of the first metatarsophalangeal joint is called hallux limitus or, with complete immobility, hallux rigidus. With impaired joint mobility, gait is altered and pressure increases on the plantar surface of the first toe (hallux), potentially leading to ulceration. Gait examination, assessment of the range of motion, X-rays of the deformity and pressure mapping will enable the clinician to determine the extent of plantar pressures and any resulting forces on the foot. See Table 4 for examples of foot deformity.

Table 4: Foot Deformity

Deformity	Example	Deformity	Example
Claw toes		**Sausage toes**	
Motor Deformity			
Hallux valgus with plantar callus *(Image permission: K. Hansen)*		**Hammertoes** *(Image permission: K. Hansen)*	
			
Hammertoes with callous and blood-filled hematoma *(Image permission: K. Hansen)*			

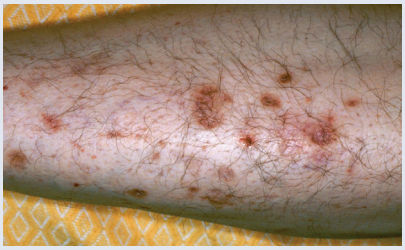
Skin and Nail Assessment

A complete head-to-toe skin assessment needs to occur, with special attention to legs and feet, including the toenails. Clinicians should identify and record any changes in skin colour, temperature, pigmentation, texture, turgor and odour, as well as assess between the toes, sole of foot and on the heels for dryness, cracks, fissures, maceration, scales or rashes (fungal infection).[1]

When examining the skin of a person with diabetes, assess for various conditions indicative of foot health status. Check for calluses (including location, size and colour [look for dark spots of dry blood in callus]), corns and non-bleeding or draining fissures or cracks, which could signal pressure points or areas of friction but are not immediately threatening. Normal, intact skin should appear healthy or dry. Particular attention should be paid to the spaces in between the toes for any hidden abnormalities. Inspection of toenails should investigate length, colour, thickness, subungual hematomas/debris, trauma, separation from the nail bed and pain. The appearance of the toenails can be a good indicator of self-care and foot health.[85,86]

A prior history of diabetic foot ulcers requires monitoring for signs of recurrence or ulcers in remission. Blisters or hemorrhagic calluses need careful evaluation for underlying issues. Fissures or cracks that are bleeding or draining indicate more severe skin integrity loss and require immediate attention. Diabetic foot ulcers, especially those not infected or covered with intact dry black eschar, highlight areas where the skin has broken down, necessitating further assessment for appropriate management to prevent infection or complications like wet gangrene.[85,86] See Table 5: Common Dermatological Conditions.

Table 5: Common Dermatological Conditions

Common dermatological condition	Example
Anyhdrosis	
Acanthosis Nigricans (AN): A condition marked by dark, velvety patches in body folds, signaling insulin resistance, often linked to obesity *(Image permission: Dr. J.L. Kuhnke)*	
Diabetic Dermopathy: Harmless, round red or brown patches on the shins, known as shin spots, resulting from blood vessel changes	 *Source: https://dermnetnz.org/imagedetail/2081-diabetic-dermopathy*

cont'd. . . .

Necrobiosis Lipoidica: Rare, painful, itchy patches, starting as bumps and worsening into swollen, hard skin	 *Source: https://dermnetnz.org/topics/necrobiosis-lipoidica*
Bullosis Diabeticorum: Blisters resembling burns on lower limbs, emerging without injury, associated with prolonged high blood sugar	
Fungal infection (person with DM) *(Image permission: Dr. R. Evans)*	
Callus *(Image permission: K. Hansen)*	 

cont'd. . . .

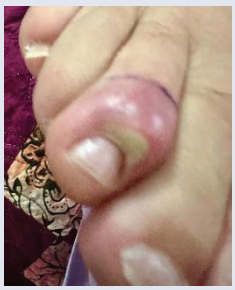
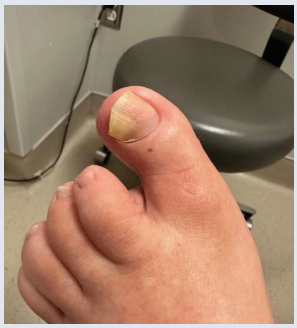
Eruptive Xanthomatosis: Tender, itchy, reddish-yellow bumps on extremities, caused by high blood fats	 *Source: https://dermnetnz.org/imagedetail/14914-eruptive-xanthoma*
Ischemia (gangrene)	

Changes in the nails of people with diabetes often stem from poor circulation, unnoticed trauma due to neuropathy and a general susceptibility to fungal infections caused by high blood glucose levels. Initial signs include discolouration, ranging from light yellow to canary yellow, often starting at the tip and moving toward the nail bed root. Dark toenails or black spots may indicate a subungual hematoma from trauma or, less commonly, a malignant melanoma, necessitating further examination to rule out cancer. See Table 6: Common Types of Nail Changes and Conditions in Persons with Diabetes.

Table 6: Common Types of Nail Changes and Conditions in Persons with Diabetes

Common nail changes	Example
Pincer Toenail: Curvature of the nail, causing potential skin breakdown and ulceration *(Image permission: K. Hansen)*	
Onychauxis: Nail thickening without deformity, often accompanied by discolouration *(Image permission: K. Hansen)*	

cont'd. . . .

Onychocryptosis (Ingrown Toenail): Nail grows into thesurrounding skin, potentially unnoticed due to neuropathy	
Onychogryphosis (Ram's Horn): Severe nail thickening and curvature *(Image permission: K. Hansen)*	
Paronychia: An infection causing redness, swelling, and tenderness around the nail *(Image permission: K. Hansen)*	
Onychomycosis: A fungal infection(deformity evident as well) *(Image permission: Wounds Canada)* *(Image permission:K. Hansen)*	 
Subungual hematoma: A collection of blood beneath the nail, often resulting from trauma. *(Image permission: K. Hansen)*	

Hand-held Infrared Skin Temperature Devices

Hand-held infrared skin temperature devices can be used to detect early signs of inflammation and tissue injury and have been validated in clinical wound assessment.[83,87-89] It has been reported that high temperature gradients between feet may predict the onset of neuropathic ulceration and that self-monitoring may reduce the risk of ulceration.[90] In a recent Canadian study, researchers reported that use of commercially available infrared thermometers (CAIT) could support patients with self-management and promote engagement in foot assessments.[91] Challenges using CAITs include how to embed their use in educational activities and choosing the most appropriate patients.[91]

It is important to note the IWGDF does not suggest using foot temperature for diagnosing diabetes-related soft tissue infection. More research is needed to address the need for well-defined and validated criteria to diagnose active Charcot neuro-osteoarthropathy.[1] The, "diagnostic accuracy of the (less than or equal to) ≤2˚C foot skin temperature measurement cutoff, that is frequently used, has not been demonstrated in a clinical study".[1] More research is needed. Also, we do not know which specific infrared thermometry device or protocol provides the most accurate method of measuring foot skin temperature. Future studies assessing the use of at-home monitoring with infrared thermometry devices to monitor disease activity would be beneficial. Daily temperature monitoring would allow the patient to liaise with the clinic without the need to attend clinic appointments as frequently and be able to identify changes in their foot condition rapidly and seek advice.[1]

Image permission: Dr. K. Stevens.

The IWGDF recommends "coaching a person with diabetes who is at moderate or high risk of foot ulceration (IWGDF risk 2-3) to self-monitor foot skin temperatures once per day to identify any early signs of foot inflammation and help prevent a foot ulcer. In case of an elevated temperature, ambulatory activity should be reduced and a member of the foot care team consulted".[1]

Footwear and Sock Assessment

Footwear, sock and orthotic assessments are key components of patient assessment, as ill-fitting footwear is a significant cause of ulcers and amputations. It is important to ensure that footwear, socks and orthotics match the person's function and activity level, address indoor and outdoor needs, are appropriate for each season and are not a source of pressure. As patients with neuropathy may not feel pain, daily foot and shoe examinations performed by patients or care partners are essential for preventing complications (pressure-related trauma, ulcers, amputations). For immersion foot please see: Chapter 5: Best Practice Recommendations for the Prevention and Management of Moisture-Associated Skin Damage.

The Self-Assessment Footwear Checklist for Patients (See Appendix F)

Patients with diabetes and their care partners should be taught about protective footwear and how to buy shoes.[92] The self-assessment footwear checklist is a tool to be completed by the patient to begin discussion about properly fitted footwear. During clinical visits, clinicians should assess the patient's shoes, socks and orthotics at every visit. Footwear that is causing harm should not be worn until reassessed by a trained foot specialist such as a podiatrist, chiropodist, orthotist or foot care nurse.[1] An area of callus build-up indicates that abnormal pressure is present, and if there is a blister, friction or shear is present. All persons with high-risk feet should be referred to a foot specialist (chiropody, podiatry, orthotics or the equivalent) if the health-care provider does not have the expertise to provide optimal plantar pressure redistribution.[93] See Figure 9 for images of ill-fitting footwear.

Figure 9: Examples of Ill-fitting Footwear

Too much wear *(Image Permission Dr. J. L. Kuhnke)*

Leather broken, too small for foot, damaged liner

Narrow toe box *(Image Permission: Dr. J. L. Kuhnke)*

Footwear too loose, heel not supported

The clinician should assess the following characteristics of each piece of footwear the patient wears (e.g., footwear for employment, leisure, walking).

- **Fit**: The toe box should be wide and long enough to prevent pressure on toes. The heel should be firm fitting but not too tight
- **Structure:** Footwear should have features that support the foot, including midtarsal support and solid heal counters. Footwear should have laces/Velcro to support the foot against the insole or liner. Footwear should not have seams or structures that could result in friction or pressure. Footwear should not have open toes or open heels
- **Cushioning**: Footwear needs enough cushioning to act as a shock absorber
- **General features**: Footwear should be made of breathable materials such as leather to allow moisture to dissipate
- **Motion control:** Footwear should limit overpronation (foot rolling inward and arch flattening)

In addition, clinicians should check inside all footwear for the presence of foreign objects, and for general wear and tear. This activity should be an 'educative moment'—explained and taught to the patient and care partner(s) so it becomes part of their daily exam activities. Footwear that is damaged should not be worn, and efforts should be made to replace it immediately.

The Care at Home Series: Caring for Your Feet: Safe Foot Care If You Have Diabetes provides steps to be followed by patients and their caregivers. Wounds Canada, Diabetes Care at Home Series.

1.2.2 Environmental: Socio-economic, care setting, potential for self-management

A significant risk factor for the development of diabetic foot complications may be the financial cost of managing diabetes. Purchasing protective footwear, prescribed offloading such as pressure redistributing devices (e.g., boots and footwear) for employment, seasonal and leisure activities is unachievable for some patients without financial support.[94-96] It is therefore essential that an environmental assessment be completed and communicated to the team to determine if the patient has the support in place to engage in a sustainable plan of care and self-management. Other determinants may include language, culture, education level, adequate housing, access to nutritious food and fluids,[97] social networks and access to services or equipment, as well as family knowledge, comfort or capacity in providing support or care.

1.2.3 Systems: Health-care support and communication

Discussion: The collective health of Canadians has a significant impact on economic performance and health-care systems. With increased chronic disease burden, including diabetes mellitus, health-care costs are increasing.[2,8] Diabetes-related care delivery is highly variable across provinces, regions, Indigenous populations and in different settings, leading to significant heterogeneity in outcomes.[3] Due to the variability, an assessment of regional services is required to determine the availability of services. To address the needs of the growing millions of Canadians living with type 1 and type 2 diabetes and pre-diabetes, an organized, interprofessional and collaborative approach to care is critical to improve diabetes-associated outcomes.[25,98]

1.3 Complete a wound assessment, if applicable

Discussion: The clinicians should identify the underlying **cause** of the wound and identify the person's **individual risk factors** and the wound should be **consistently** assessed using a validated tool and the findings communicated to the integrated team.[1] Wound assessment can help clinicians determine wound healing ability, plan treatment, facilitate communication, monitor treatment and predict and verify outcomes (e.g., healing and recurrence). It also helps identify additional complexity that may contribute to barriers to healing (e.g., depression, substance use, including smoking, access to services, care partner burnout, and health literacy).

Wound assessment tools

Assessment of skin, wound and periwound skin and documentation of findings requires a standardized approach.[99] Clinicians should use a comprehensive, validated and reliable wound assessment tool to provide a baseline and to assist with identifying any wound changes, as well as communicate with the team in a standardized manner. This information helps identify wound healing or deterioration and should guide ongoing treatment decisions. It also provides a consistent communication means among team members.[99]

For more on wound assessment tools, see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[24]

Wound culture specimens

If infection is not suspected based on the clinical assessment, specimens for culture must not be collected and antibiotic treatment is not required.[77] Obtaining specimens for culture is recommended only for clinically infected wounds prior to initiation of antibiotic therapy.[77] The specimen for culture should be obtained following wound cleansing and debridement. Surface swabs most often do not reflect the microbiology of deeper tissues.[100]
The sample for microbiological assessment ideally should be obtained aseptically by curette or biopsy.[1] If bone is involved, the recommendation is to obtain a bone biopsy for culture based on the presentation and local resources.[1]

Probing to bone is indicative of bone involvement and suspect of osteomyelitis.

The IWGDF states that use of a universally recognized classification of the foot ulcer facilitates communication among teams, enhances research and improves patient outcomes by allowing for precise patient stratification, accurately characterizing DFUs and providing actionable treatment insights. Despite the lack of universally accepted systems, the existing ones play a crucial role in guiding clinical decisions.

SINBAD classification system[1]

The SINBAD (site, ischemia, neuropathy, bacterial infection, area and depth) classification system focuses on a methodical approach to thoroughly describe ulcer characteristics. It incorporates the following key elements:

- **Site**: Determine location of the ulcer,--forefoot, midfoot, or hindfoot.
- **Ischemia**: Assess if pedal blood flow is intact (at least one palpable pulse), or if there is clinical evidence of reduced blood flow. Examine the arterial pedal wave forms via ABPI or TBPI.
- **Neuropathy:** Assess if there is loss of protective sensation.
- **Bacterial infection**: Assess if clinical infection is present by assessing for the presence of at least two clinical signs or symptoms of inflammation (redness, warmth, induration, pain/tenderness) or purulent secretions. Note: these signs may be blunted by neuropathy or ischemia, and systemic findings (e.g., pain, fever, leukocytosis) are often absent in mild and moderate infections. Classify infection using the IWGDF/IDSA grading as mild (superficial ulcer with minimal cellulitis), moderate (ulcer deeper than skin or more extensive cellulitis, with or without abscess) or severe (accompanied by systemic signs of sepsis), with or without osteomyelitis.
- **Area:** Measure ulcer size (using a validated tool).
- **Depth:** Assess the ulcer depth and classify as: confined to skin and subcutaneous tissue; reaching muscle or tendon; or reaching bone. Determining depth can be difficult, especially in the presence of overlying callus or necrotic tissue. To aid assessment, debride any neuropathic or neuro-ischemic ulcer that is surrounded by callus or contains necrotic soft tissue at initial presentation, or as soon as possible. Do not, however, debride a non-infected ulcer that has signs of severe ischemia. Neuropathic ulcers can usually be debrided without the need for local anesthesia.[1]

The SINBAD classification system is graded on a binary scale (0 or 1 point), leading to a total possible score range from 0 to 5. This scoring system is designed to reflect the ulcer's severity incrementally. Its simplicity and reliance on standard clinical examination without the need for specialized equipment make the SINBAD system both accessible and practical for routine use. For example, patients with a higher SINBAD score have a lower chance of being alive and ulcer-free at 12 weeks and a higher risk of experiencing a major amputation at six months.[1] The SINBAD system has demonstrated moderate inter-observer and excellent intra-observer reproducibility, underscoring its reliability in tracking the progression of DFUs, including healing outcomes and the potential need for amputation.[1]

Wound, Ischemia, and Foot Infection (WIfI) classification system[1]

The WIfI classification system was introduced to evaluate three critical risk factors for lower limb amputation: wound, ischemia and foot infection. The WifI system assigns a score from 0 to 3 for each factor. Wounds are graded based on size, depth, severity and the anticipated difficulty of healing; ischemia is assessed through ABI gradations; and foot infections are evaluated by their scope and depth.[1]

This scoring system supports predicting the likelihood of major amputations in patients with diabetes-related ulcers and vascular disease, recommending its use for assessing perfusion and vascular function to facilitate timely revascularization and/or wound drainage interventions. However, due to the need for specialized vascular measurements, the WIfI system's application is more suited to settings with existing expertise in vascular interventions, indicating its limited utility in primary or community care contexts.[1]

The IWGDF/ISDA classification

The Infectious Disease Society of America and the IWGDF state that the diagnosis and classification of infection is based on clinical signs and symptoms,[1,101] The inflammatory response (erythema, warmth, tenderness, pain and induration, and loss of function) may be blunted in people with diabetes due to peripheral neuropathy, peripheral vascular disease and hyperglycemia. Secondary signs of infection, which may be useful in diagnosing infection, include the presence of necrotic tissue, friable granulation tissue, the type and amount of exudate and increased pain and odour. The severity of the infection should be defined based on the extent, depth and presence of systemic findings.[102-104]

For each classification system for diabetic foot ulcers there are advantages and disadvantages. See Table 7.

Table 7: Common Classification Systems for Diabetic Foot Ulcers[1]

System	Description	Comments
SINBAD	Site, Ischemia, Neuropathy, Bacterial infection, Area Ulcer, Depth	• Simple and quick to use • Requires only clinical examination • Contains necessary information to communicate for triaging purposes
WIfI	Wound Ischemia and Foot Infection Ischemia: based on ABPI or $TcPO_2$, Infection: based on the IWGDF criteria	• Estimates the risk of amputation and potential benefit of revascularization • Co-morbidities are not included • With confirmed infection and diagnosed peripheral artery disease, with vascular surgical expertise available this system should be considered
IWGDF/ IDSA	Classification system for the extent of infection and guide for management	• Assesses the severity of infection based on levels (1–4) • Diagnosis is based on local or systemic signs and symptoms of • inflammation • Adds the presence of bone infection to the level (e.g., 3 [O-osteomyelitis])

One aspect of assessment of diabetic foot ulcers is seeking the underlying cause/etiology. To create an optimal plan of care, the wound needs to be assessed and categorized as neuropathic, ischemic or neuroischemic.[1] Categories of diabetic foot ulcers outline some of the features most commonly associated with each of these etiologies. (See Table 8).

Table 8: Categories of Diabetic Foot Ulcers[105]

Feature/Etiology	Neuropathic	Ischemic	Neuroischemic
Sensation	sensory loss	pain	degree of sensory loss
Callus/necrosis	callus present and often thick	necrosis common	minimal callus; prone to necrosis
Wound bed	pink and granulating, surrounded by callus	pale and sloughy with poor granulation	poor granulation
Foot temperature and pulses	warm with bounding pulses	cool with absent pulses	cool with absent pulses
Other	dry skin and fissuring	delayed healing	high risk of infection
Typical location	weight-bearing areas of the foot, such as metatarsal heads, the heel and over the dorsum of clawed toes	tips of toes, nail edges and between the toes and lateral borders of the foot	margins of the foot and toes
Prevalence[90]	35%	15%	50%

Permission granted by Wounds International.

Mobile phone applications are being used to monitor wound size and characteristics with potential options to communicate with other care providers on the team. However, a pan-Canadian study[106-108] suggested challenges due to lack of organizational policy and procedure, cost of devices for clinicians, patients and care partners, access to stable internet services and standardized app education and use among teams and organizations. More research is needed.[109]

Diabetic Foot Osteomyelitis

Osteomyelitis is an infection in the bone(s) of the foot of a person with diabetes.[110] Osteomyelitis in the diabetic foot is a highly challenging diagnosis.[111] It can occur in 60% of hospitalized patients with diabetic foot infections and in up to 20% in outpatients with less severe infections.[102] Clinical presentations may vary greatly based on the involved site, extent of infection, perfusion, presence of surrounding infection and causative organism(s).[102] Osteomyelitis should be suspected when ulcers lie over a bony prominence and fail to heal in spite of offloading or when they have associated soft tissue induration ('sausage toe' appearance).[112,113]

Diabetic foot osteomyelitis commonly involves the forefoot and occurs by contiguous spread of infection from overlying soft tissues through to the underlying bone. A definitive diagnosis of diabetic foot osteomyelitis requires both histologic evidence of bone infection and isolation of a bacterial pathogen from a bone sample;[114] however, this is not always practical. In a 2021 review, researchers discussed a shift in surgery: major amputations were once common for osteomyelitis, but now, with improved diagnostic and surgical techniques, foot-sparking or conservative surgical approaches (resecting only the infected and necrotic bone) are becoming common, especially for forefoot infections.[111] In addition, antibiotic therapy, which has traditionally been administered predominantly intravenously and frequently over several months, is now being replaced by, "appropriately selected oral antibiotic regimens following only a brief (or even no) parenteral therapy, and given for no more than 6 weeks".[111]

Diagnostics

As bone biopsies are not routine in all clinical settings, diagnosis of osteomyelitis is made based on clinical assessment, laboratory and radiographic features. Diagnostic accuracy is critical to guide management. The IWGDF states that to diagnose osteomyelitis of the foot in a person with diabetes consider using a combination of plain X-rays, probe-to-bone test and lab tests (erythrocyte sedimentation rate, or C-reactive protein or procalcitonin) as the initial studies.[1] Probe to bone is a concern, and the patient must be evaluated for the possibility of osteomyelitis.

The probe-to-bone (PTB) test is a useful clinical tool when employed correctly for the diagnosis of osteomyelitis, "in combination with abnormalities on plain X-ray; high levels of ESR, CRP, or procalcitonin".[1] A sterile blunt metal probe is inserted through a wound and if bone is struck (hard, gritty end-feel), the likelihood of osteomyelitis is greatly increased in populations with high prevalence of osteomyelitis, such as persons with diabetes.[115-117] In 2016, Wrobel and Schmidt reviewed six PTB studies. The reported osteomyelitis prevalence varied from 22% (outpatient setting) to 55% for patients in the outpatient setting with infected ulcers and 70% in hospitalized patients. They state the PTB test provides important information where the, "likelihood of osteomyelitis is low after a negative test in the outpatient or low-risk setting. The likelihood is high after a positive test in a high-risk or inpatient setting".[118]

When considering radiographic evaluation, clinicians should be aware that plain X-rays are often adequate to evaluate the bone for established osteomyelitis.[1] They are also useful for assessing foot deformities, fractures, the presence of gas in the soft tissue and radiopaque foreign bodies. Bony changes seen on plain X-rays can be slower to develop, but X-rays are low-cost and readily available, and if there is any concern of osteomyelitis, serial plain X-rays may demonstrate the evolution of radiographic changes of osteomyelitis. Plain X-rays have sensitivity of 61.9% and specificity of 78.3%,[119] demonstrating that they should not be used in isolation, as they are not highly predictive of osteomyelitis regardless of the result. X-rays have poor positive predictive value, even when they are positive, unless subsequent radiographic evidence is positive.

Blood tests for inflammatory markers such as WBC, C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), or procalcitonin (PCT) in a person with diabetes and a possible infected foot ulcer are often used but are not specific to the type of infection.[1] An ESR elevated to more than 70 mm/hr increases the likelihood of osteomyelitis and lower levels can decrease the likelihood.[1] An ESR may be a useful biochemical adjunctive test.[1] There is insufficient evidence, however, for routine use of these biochemical tests for diagnosis of diabetic foot osteomyelitis. Of these, as ESR drops more slowly with treatment, it may serve as a marker for treatment response.[1]

Magnetic resonance imaging (MRI) is considered the gold standard for diagnosing osteomyelitis as it gives a good review of soft tissue anatomy as well as joints and bones.[1] When MRI is contraindicated, or not available, a WBC labelled radionuclide scan, computed tomography or positron emission tomography may be considered.[102] While these techniques are helpful in diagnostic dilemmas, their availability may be limited and prior to requesting them it is important to discuss with a radiologist the most appropriate diagnostic imaging technique for the patient's specific clinical scenario.

Step 2: Set Goals

Discussion: Based on identified risk factors and complete patient, skin, wound and environmental assessments, goals of care (there may be several) need to be set in collaboration with the patient, family and/or care partner using the SMART principle. See Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview.[24] Identify the available options so that informed decisions can be made. Health-care providers must respect the individual's right to choose the interventions they prefer.[25]

Recommendations

2.1 Set goals for healthy skin, prevention of foot trauma, management of healing, non-healing and non-healable wounds

Discussion: From a long-term health perspective, a primary goal for those with diabetes should involve promotion of foot health and the prevention of diabetic foot ulcers. Therefore, factors that can cause skin breakdown or influence healing need to be identified so they can be addressed in the goal-setting stage.[25,120] Reducing the risk of neuropathy and peripheral arterial disease should also be considered.

2.1.1 Identify goals based on skin health and prevention or healability of wounds

Discussion: Promotion of skin health is key for persons with diabetes. Prevention of an initial wound or additional wounds on the contralateral limb or other parts of the foot is a goal that should be given paramount consideration. Ultimately, preservation of limbs and life may depend on it. In the presence of wounds, the health-care professional must identify whether the wound is healing, non-healing or non-healable. This decision is made based on the patient's modifiable and non-modifiable risk factors and is the only way to ensure that the goals are made in conjunction with, and are appropriate to, the patient.[5] See Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview[24] for more on goal setting in general.

Diabetes Canada offers the ABCDEFSSS scheme for patients to improve communication with care providers and to support goal setting.[121]

A – A1c – Aim for a glucose control target of 7% or less, and link glucose levels to foot health. For example, set a target for one month.
B – Blood pressure – Aim for a blood pressure control target of less than 130/80 mmHg. For example, set a target for four to six weeks.
C – Cholesterol – Aim for an LDL target of 2.0 mmol/L or less. For example, set a target of 90 days.
D – Drugs – Protect against heart attack and stroke with appropriate medication. Drugs to decrease heart disease risk include: blood pressure pills (ACE inhibitors or ARBs), cholesterol-lowering pills (statins), medications that lower blood sugar with proven heart benefit, or ASA (Aspirin).
E – Exercise and healthy eating – Participate in regular physical activity and follow a healthy dietary pattern. Strive to complete at least 150 minutes of moderate-to-vigorous-intensity aerobic exercise each week (e.g., 30 minutes, five days a week) and resistance exercises (like lifting weights) two to three times a week. For example, set a target of 30 to 60 days.
F – Foot care and footwear for all seasons plus socks – Perform a daily examination. For example, set a target of 7 to 14 days.
S – Self-management support – Set goals and identify barriers that may prevent you from reaching your goals.
S – Screen and monitor for complications related to heart, feet, kidneys, eyes, and changes to mental health.
S – Smoking and stress – Stop smoking and manage stress effectively. For example, set a target date of 30 days.

Modified with permission from Diabetes Canada.

2.1.2 Identify quality-of-life and symptom-control goals

Discussion: Health-care professionals must remember the patient's goal(s) of care may be several and not necessarily aligned with those of the health-care providers. Goals related to healing wounds may take time and be complex. It is crucial that the team be well-organized, use a holistic health approach and include care partners and families.

Goals of care should be considered and established according to the SMART principle.[24]

Goals should be relevant to skin and foot health, mental health and wellbeing and, especially, urgency and timeliness to wound assessment and healing, pain reduction, odour, controlled infection, frequency of dressing changes and need for offloading.[25,120] Measuring patient outcomes using validated tools is important for research, education and to understand the need for system changes. This includes identifying patient-reported outcome measures (PROMS) that capture the experiences of patients while living with wounds.[122]

A special note on pain: Reducing painful diabetic neuropathy can be a key goal for patients living with diabetic foot complications. According to the Diabetes Canada guidelines, few patients have complete relief of painful symptoms with any treatment, and reduction of 30 to 50% in pain levels is clinically meaningful.[28] For example, a goal might be that neuropathic pain is controlled in three to seven days with regular reassessments of progress.

Many clinicians struggle with the decisions surrounding limb preservation and need support when exploring all goals of care with the team. It is important to note that some patients may elect to undergo amputation, as the wound may be interfering with their occupation, mental health, social and family support systems, access to care and financial resources.

Step 3: Assemble the Team

Discussion: Assessment, prevention and management of patients at risk for, or with, diabetic foot problems require the collaboration of an integrated team across all health-care sectors. The team must work closely and collaboratively to address the complex lifestyles, self-care strategies, emotional health, language and culture, as well as the social impacts of living with diabetes and being at risk for foot complications. Clinicians require clear protocols and clinical pathways that reflect the continued and integrated care needs of patients across all settings and that can be communicated among all team members.[17]

Recommendations

3.1 Identify appropriate health-care professionals and service providers

Discussion: The professional members of the team need to be trained and enabled to work with patients with diabetes and their care partners since the knowledge and skills necessary to assess and treat the person at risk for, or with, diabetic foot complications are not usually taught in an entry-level health-care professional curriculum. Caring for such individuals requires clinicians have the skills to address glycemic control (in relation to foot health), infection control, offloading of high-pressure areas, lower-extremity vascular status and local wound care, while supporting a self-management approach to care.[28] For more information visit Your Foot Care Team.

Patients and Their Care Partners First

The first team members are the patient, then their family or care partners. The next team member is usually the primary care provider, depending on the needs of the patient and allocation of resources within the community. We recognize this is a challenge across Canada as many individuals do not have a primary care provider,[123,124] potentially putting those with diabetes at greater risk.

Integrated teams may include: a diabetologist, specialist in internal medicine, diabetes nurse specialist, podiatrist/chiropodist, orthotist, pedorthist, nurse and rehabilitation professionals, a nurse specialized in wound care/foot care and pharmacist. In some cases, there should be contact with specialists in endocrinology, renal dialysis, dermatology, vascular surgery, microbiology, orthopedics and infectious diseases, as well as social workers, psychologists, cultural/ethnic health liaisons, registered dietitians, spiritual care providers, Indigenous elders and mental health workers.[24,25,120,125]

To manage diabetes-related health, foot health and foot complication issues, there may be a combination of face-to-face, virtual, web–based and/or hybrid strategies in place to promote access to care and communication.[126] Each strategy must be focused on patient and care partner needs and ensuring that effective collaboration and communication result.[120]

Patients with disabilities, including visual impairment and mental health issues, or those who are living unhoused, housebound or living in specialized care settings, may need further support.[120] Additional considerations for assembling the appropriate team are as follows.

- Specialized assessment equipment and training are required to assess the vasculature of a person with diabetes.[25,120] Appropriate referral for any patient diagnosed with, or suspected of, arterial insufficiency is essential for the prevention and treatment of diabetic neuropathic foot ulcers.
- If a person with diabetes is admitted to acute care where a diabetic foot problem is the dominant clinical factor for admission, acute care protocols and care pathways should be in place to support care delivery.[120] In the acute care setting, the patient needs to be assigned to a lead clinician who can ensure that timely care is provided.[120] In the United Kingdom, patients with diabetic foot complications access the multidisciplinary foot care team to enforce limb preservation strategies. This effective model needs to be considered in the Canadian health-care system.
- Clinicians and other professional team members involved in the assessment and treatment of diabetic feet should receive competency-based education and training.[1,127,128] Guidelines from the UK's National Institute for Health and Clinical Excellence (NICE) refer to engaging trained health-care professionals.[120] Since early detection and intervention may be the key to more successful outcomes, access to individuals with knowledge and training specific to diabetes and diabetic foot care will improve patient outcomes. In addition, professionals need to recognize the impact of living with neuropathy, which can reduce motivation to heal or prevent injury.[25,120]

Terminology

Multidisciplinary team refers to a team of health-care workers from a variety of disciplines. The IWGDF states a multidisciplinary team is a group of, "people from relevant clinical disciplines, whose interactions are guided by specific team functions and processes to achieve team- and person-defined favourable" outcome(s).[1]

Integrated team is the preferred term because it describes a team that includes the patient, care partners, family and a mixture of professional and paraprofessional providers.

Professional Team Members Guidelines (Modified from IWGDF, 2023).

Levels of care for diabetes-related foot disease	
Low Risk (Category 0)	Primary care provider (nurse practitioner, family physician), podiatrist, diabetes/foot care nurse, registered dietitian, physiotherapist, and occupational therapists who have been trained in diabetes foot screening
Moderate Risk (Category 1)	Diabetologist, surgeon (general, orthopedic, foot/ podiatric), vascular specialist (endovascular and open revascularization), infectious disease specialist or clinical microbiologist, podiatrist and diabetes nurse, in collaboration with a pedorthist, orthotist or prosthetist
High Risk (Category 2)	Foot centre specialized in care for diabetes-related foot disease, with multiple experts from several disciplines, each specialized in this area working together, that acts as a tertiary reference centre
Very High Risk (Category 3) or Urgent Risk	Specialized wound care team

3.2 Enlist the patient and their family and care partners as part of the team

Discussion: Patients with, or at risk for, diabetic foot complications and their care partners need to become part of a specialized, integrated diabetes team that is proactive, incorporates elements of the chronic care model (CCM) and is organized around them.[28] For pediatric patients, parents or legal guardians need to be part of the care-planning team.[129] Ideally, the patient and care partners are willing and able to set goals and participate in the development and implementation of any plan of care. Every attempt should be made to have meaningful communication with the patient and family—especially during transitions in care—regarding lifestyle choices that will result in the best possible long-term outcomes.[25,129]

To help ensure active participation, individuals with diabetes and their care partners should be offered timely, relevant diabetes information that is tailored to enhance self-care/management practices and behaviours.[130] Diabetes self-management, education and support (DSMES) is defined as a planned, co-created systematic intervention that involves

active patient and/or care partner participation in self-monitoring (physiological processes) and/or decision-making (managing). It includes a, "comprehensive blend of clinical, educational, psychosocial and behavioural aspects of care needed for daily self-management and provides the foundation to help all people with diabetes avigate their daily self-care with confidence and improved outcomes".[130]

A more informed patient is likely to be a more engaged team member. Wounds Canada has developed resources to help patients increase their knowledge of diabetes-related foot management. These include:

Care at Home Series: Caring for Your Feet: Safe Foot Care If You Have Diabetes, a simple guide that can be used by patients with diabetes and their care partners for caring for their feet at home. https://www.woundscanada.ca/docman/public/patient-or-caregiver/1728-home-safe-df-care-1942e/file

Care at Home Series: Diabetic Foot Complications When Is It An Emergency?, a guide to help patients with diabetes recognize causes and techniques for preventing foot complications and when to notify a health-care provider when changes occur. https://www.woundscanada.ca/docman/public/patient-or-caregiver/1727-home-emergency-df-care-1941e/file

Wounds Canada FIY series. Neuropathic/diabetic Foot Ulcer: What Is It? (2021). https://www.woundscanada.ca/patient-or-caregiver/resources/diy-series

Peer or lay educators may also increase diabetes-related knowledge and self-care behaviours.[28] The Diabetes, Healthy Feet and You program is an example of a peer-reviewed, peer-led, patient-focused program that provides supportive educational sessions on diabetic foot care. It is delivered to people with diabetes and their family members byfacilitators living with diabetes, alongside clinical experts. This approach gives patients the opportunity to ask clinical questions while also learning from the lived experience of peer educators.[131,132]

3.3 Ensure organizational and system support

Discussion: Management and prevention of diabetes-related foot disease necessitate a comprehensive, multidisciplinary approach, emphasizing the holistic treatment of foot complications as indicators of broader health issues. This approach requires an organized system with specific guidelines covering all standard care aspects, tailored to accommodate local resources and staffing variances. Essential elements of such care include extensive education for individuals with diabetes, their care partners and health-care professionals in both hospital and primary care settings. Moreover, it involves systematic screening to identify at-risk individuals, including mandatory annual foot examinations for everyone with diabetes, ensuring access to preventive measures like podiatric care and specialized footwear and providing timely, effective interventions for foot ulcers and infections.[1]

This organized care approach encompasses rapid access to revascularization procedures, techniques for ulcer off-loading and comprehensive wound care protocols, including regular inspections and appropriate dressings. Auditing services play a critical role in this framework, ensuring practices meet high standards of care and addressing any service shortcomings. The guidelines suggest that diabetes-related foot care should operate within a structure designed for chronic care management rather than being limited to responding to acute incidents. Ideally, a tiered foot-care management system should exist, involving interdisciplinary specialists at all levels to cater to the complex needs of individuals with diabetes, thereby reducing the risk of foot ulceration and improving overall patient outcomes.[1]

Successful diabetic foot care programs are designed and evaluated in collaboration with patients, care partners, clinical practice leaders, educators, researchers and administrators at the institutional, regional and provincial/territorial levels.[25] It is important to establish trust-filled relationships with patients and their care partners/family members to fully engage them in care.[1,25,120]

It is crucial that care be co-ordinated between health-care agencies and the community and promote a standardized approach to wound prevention and care to improve and measure patient outcomes and efficiency; this is especially important when patients transition between care settings.

- Successful programs involve formalized collaboration between the patient, care partners and acute, long-term, primary and community care to align best practices across the health care sectors.
- Teamwork and integration of services help to ensure clear, culturally safe, trauma-informed systems communication, reduce duplication of services and promote measurement of patient, care partner, clinicians and system

outcomes.[25,120] Organizations and leaders are encouraged to do the following, all of which are reinforced by Diabetes Canada.[25,28,120]

- Develop policies (federal, provincial/territorial, regional and local/institutional) that are relevant and acknowledge and designate human, material and financial resources to support the team in the prevention of diabetic foot complications and diabetic foot ulcer assessment, prevention and management.

Why Integrated Teams Are Important

Integrated teams and interprofessional teamwork are key to successful diabetes prevention, assessment, treatment and management.[25,28,120] Teams should:

- Establish a pathway for referral, from immediate, to 48 hours, to a multidisciplinary foot-care service of people with diabetes that supports risk stratification
- Work with community and other partners to develop a process to facilitate patient referral and access to local diabetes resources and health-care professionals with specialized knowledge in diabetes management (e.g., glycemic control, A1c)
- Work with community and other partners to advocate for strategies and funding for all aspects of preventative foot care, preventative and treatment footwear and glycemic control
- Ensure foot care services exist for the assessment, surveillance and treatment of preventative care
- Establish and support a multidisciplinary team composed of interested, skilled and knowledgeable individuals to address and monitor quality improvements in the promotion of skin health, and prevention and management of diabetes-related foot complications
- Use globally recognized risk classifications to help allocate resources such as therapeutic shoes, patient education and clinical visits
- Establish and sustain a communication network among the person with diabetes, care partners, health-care professionals and community systems
- Audit (measure outcomes) all aspects of the service to ensure that local practice meets accepted national and international standards of care
- Engage patients with diabetes to check their feet daily for cuts, cracks, bruises, blisters, sores, infection and unusual markings
- Advocate for your patients with diabetes to ensure they are supported by policies, practice, resources and support. Visit the Diabetes Canada advocacy web page for information and resources. https://www.diabetes.ca/advocacy---policies/advocate-for-diabetes-canada

Step 4: Establish and Implement a Plan of Care

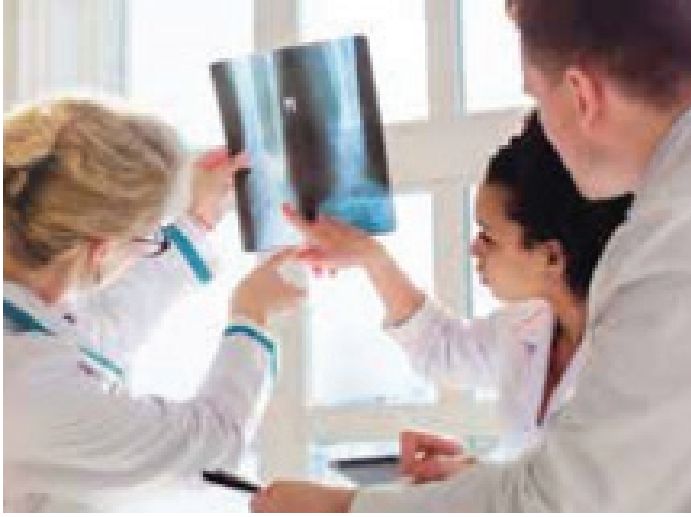
Discussion: Foot skin health, foot ulcer prevention and wound healing are challenging in individuals with diabetes, as the disease presents many complex prevention and management issues. The plan of care should incorporate the multiple factors identified during the assessment process.

Recommendations

4.1 Identify and implement an evidence-informed plan to support healthy skin, to correct the causes or co-factors that affect skin integrity, including patient needs (physical, emotional and social), the wound and offloading (if applicable) and environmental/system challenges

Discussion: Maintaining healthy feet and the prevention of diabetic foot complications is key. All individuals at risk for and living with diabetes need to receive at least annual foot screenings to identify whether they are at low, moderate, high, very high or urgent risk for the development of foot complications. Management strategies can then be developed that revolve around the prevention and/or management of diabetic foot risk as seen in Step 3 of the Inlow 60-second Diabetic Foot Screen.[32]

Whether or not the person with diabetes has an ulcer, the patient and health-provider team should work together to monitor and manage the factors that affect the patient's health and wellbeing, including smoking, glycemic control, weight-management, use of medications, level of physical activity, exercise and occupation, professional foot care and offloading and behaviours such as completion of daily foot self-examination, recognizing and managing foot injury, accessing care and acquiring and wearing appropriate footwear.[28,120]



There are critical times to offer regular and repeated education and diabetes self-management education and support.

- When engaging in promotion of health activities, nutrition and mental health and wellness[129]
- At diagnosis and during preventative foot-screening activities
- Annually, and/or when targets of treatment are not being met
- When complications arise
- When transitions in life and care occur[130]

For more information on Diabetes, Healthy Feet and You see: https://www.woundscanada.ca/for-patients-public/240-diabetic-healthy-feet-and-you/for-patients-and-public/267-information-about-diabetes-and-healthy-feet

The patient, care partner and family must work with the integrated team to ensure care plans are co-created, balanced and remain focused on the patient preferences and informed decisions. Care plans will include multiple topics such as: daily foot and skin checks, emotional wellbeing, smoking cessation, glycemic control, weight-management, medications[28] and physical activity.

When a wound is present, the care plan will include wound assessment, pain, vascular status, infection, and day-to-day management. Teams also need to include conversations about home life, financial responsibilities, employment (shift work), occupation(s), access to professional foot care and offloading and behavioural options.[25,129]

Care planning sessions take time, a commitment to listen to the patient's responses, a willingness to co-create and negotiate care and assessment of the person's ability to cope with the complexities of diabetes, skin health and/or a foot ulcer. Teams need to recognize early the need for timely and urgent care to manage a foot injury, accessing care and acquiring and wearing appropriate footwear for all activities, including employment, social, physical and at home.

Support for Self-managed Care/Education

- Support your patient in self-managing their care to prevent foot complications by having them do the following (accompanied by your activities in parentheses)
- Manage their blood glucose levels (discuss links to foot health)
- Stop smoking if they are a smoker (discuss links to vascular disease)
- Perform a daily foot exam (promote foot hygiene)
- Manage lower leg edema[133]
- Select professionally measured shoes, if they have neuropathy
- Perform high-quality foot and nail care and hygiene
- Seek professional foot care through podiatrist, chiropodist, or foot care nurse
- Seek help with urgent foot complications
- Ensure they receive an annual foot screen (train your relevant team members)[28]

Skin and nail care

Ensure that the person with diabetes has a skin- and nail-care routine that supports the maintenance of healthy feet. Skin should be assessed frequently for signs of impending injury. Callused areas require debridement and footwear adaptation/offloading as needed to prevent injury or recurrence of a wound. Heel cracks or fissures should be treated with debridement and appropriate dressings, as well as appropriate footwear, to reduce pressure and shear. Foot odour may indicate poor hygiene or a fungal infection, also known as athlete's foot, that requires treatment with antifungal therapy as well as attention to footwear to ensure it is breathable and hygienic. Ragged and unkempt nails may require professional and routine follow-up.[134]

Medication Management

Patient-centred care in diabetes management encompasses optimizing glycemic control with tailored oral antihyperglycemic medications, nutrition, and/or insulin therapy, addressing edema, malnutrition and cardiovascular risk factors,

while also recognizing and screening for and treating underlying psychosocial challenges such as diabetes distress[135] and depression and anxiety.[1]

Cardiovascular Management

Cardiovascular disease screening and management are crucial, as adults with diabetes have a two-four times increased risk compared with adults without diabetes,[136] and the risk rises with worsening glycemic control. Researchers report a 75% increase in mortality, with cardiovascular disease being a large contributor. Medication management should be focused on reduction of macro- and microvascular complications, coronary heart disease, strokes, heart failure, PAD, renal disease and vision changes.[136]

All patients with diabetes and an ischemic foot ulcer should receive aggressive cardiovascular risk management that may include support for cessation of smoking, treatment of hypertension and prescription of a statin as well as low-dose acetylsalicylic acid or clopidogrel.[1,137]

Glycemic Control

Appropriate glycemic control is essential for delaying complications of diabetes in adults and children, and for theprevention of foot complications and for wound healing.[138] The IWGDF emphasizes the relationship of glycemic management to wound healing by stating, "when the wound deteriorates or fails to significantly improve (e.g., a less than 50% reduction in wound area within four weeks) despite appropriate infection and glucose control, wound care, and offloading, reassess the vascular status and consult with a vascular specialist regarding possible revascularization."[1]

A glycated hemoglobin (A1c) test shows blood glucose levels over the previous three months.[139] Although glycemic targets must be individualized, most people with diabetes should aim for an HbA1c level of less than 6.5% to reduce the risk of micro- and macrovascular complications.[28] An increasing number of studies have, however, demonstrated significantly decreased healing times in individuals with lower A1c,[140] though not all researchers agree and more research is needed.[141]

Although it is clear from the literature that tight glycemic control prevents or delays the complications of diabetes, there is a growing body of literature discussing the A1c level as a good criterion for evaluating foot ulcer incidence, predicting the progression of foot ulcers and increased treatment duration and depth of the wound.[142] If poor glycemic control is suspected, the clinician should refer the patient to their primary care provider, diabetes educator or other specialist, as appropriate, for consideration of services, technologies or devices that could support glycemic control.[1]

Smoking Reduction/Cessation

The effects of smoking on health and when living with diabetes are well documented.[143] Every effort should be made to encourage and support smoking cessation in individuals living with diabetes and/or with a foot ulcer. Fu and colleagues showed that there is a significant risk for foot amputation when patients smoke. As well, they found an association between cigarette smoking and delayed diabetic foot healing.[144] Clinicians should refer patients and their care partner to smoking cessation programs to address this crucial modifiable risk factor.[1]

Pain Management

To support pain control, gabapentinoids, tricyclic antidepressants and serotonin-norepinephrine reuptake inhibitors are the first-line agents for treating neuropathic pain.[145] Tramadol and other opioids are recommended as second-line agents, while cannabinoids are newly recommended as third-line agents. Other anticonvulsants, methadone, tapentadol, topical lidocaine and botulinum toxin are recommended as fourthline agents.[145]
Opioids are avoided and only used when other treatments fail.[146] Other effective therapeutic options include topical nitrate sprays, topical capsaicin and transcutaneous electrical nerve stimulation.[28]

Footwear and Offloading

Prevention of ulceration or re-ulceration in the feet of individuals with diabetes is possible when pressure is taken off vulnerable plantar areas and friction is eliminated. This is achieved through proper fitting, use and inspection of insoles and footwear. Those with compromised sensation need the assistance of regular visual and hand inspection by themselves and their support team. Also, their footwear should always be professionally fitted. (See Table 9: Footwear for People with Diabetes).

It is important that the entire team be aware of the following footwear selection and wearing protocols for prevention of foot complications. Therapeutic footwear or orthotics must be worn at all times, both indoors and outdoors. Inappropriate footwear such as high-heeled or narrow-toed shoes should be avoided, as these can cause damage even if worn for only a few hours.[147]

Table 9: Footwear for People with Diabetes[148]

Risk Level	Low to Moderate Risk for Foot Ulceration	Moderate to High Risk for Foot Ulceration	Active Foot Ulcer(s)
Actions Required	Wear properly fitting and protective footwear that accommodates the shape of feet; wear socks to minimize shear and friction	Ensure proper fit, protection and accommodation of the foot's shape. Wear footwear at all times, both indoors and outdoors. Inspect footwear each time before use for foreign objects Examine feet after removing footwear for signs of pressure, trauma or ulcers For those with foot deformities or pre-ulcerative lesions, medical grade footwear, possibly including custom-made orthoses or insoles, is recommended Patients with healed plantar foot ulcers should use medical grade footwear with custom orthoses or insoles proven to reduce plantar pressure in high-risk areas. It's advised to review the effectiveness and fit of the prescribed footwear every three months to ensure ongoing protection and support	Prescribe appropriate offloading devices to heal ulcers. See: Product Picker: Offloading Plantar Pressures in Diabetes

Adapted from: van Netten JJ, Lazzarini PA, Armstrong DG, Bus SA, Fitridge R, Harding K, et al. Diabetic Foot Australia guideline on footwear for people with diabetes. J Foot Ankle Res. 2018 Jan 15;11:2.

Offloading is a fundamental treatment for foot ulcers caused by increased mechanical stress. Initial steps involve the use of non-removable knee-high devices, like total contact casts, to alleviate mechanical stress on neuropathic plantar ulcers. See Table 10 to identify factors to consider when offloading the foot of a person with diabetes.

In situations where such devices are not feasible, alternatives like removable offloading devices and felted foam, paired with appropriate footwear, are considered. Additionally, specific interventions such as digital flexor tenotomy are employed for ulcers resulting from toe deformities, with a careful approach adopted in the presence of infection or ischemia.

See Wound Canada's Offloading Plantar Pressures in Diabetes to understand the advantages and disadvantages of each. https://www.woundscanada.ca/docman/public/health-care-professional/1214-wc-product-picker-offloading-ltr-1703e/file

Table 10: Factors to Consider When Offloading the Foot of a Person with Diabetes

Factors	Description
Disease	• neuropathy • vision • PAD • inflammatory disorder
Pressure	Type of pressure • shear pressure • vertical pressure Intrinsic • structural modifications (deformity/limited range of motion/ tissue quality loss) • infection • malignancy Extrinsic • biomechanics • deformity • footwear
Foot ulcer recurrence	• presence of ulcer • type of ulcer/re-ulceration • location • dressing selection
Physical activity/ culture	• occupation with physical demands, footwear requirements • home lifestyle • sports/recreational activity • balance and exercise plan
Funding	• ability to pay for device, footwear etc. • third-party insurance
Psycho-social/spiritual care	• cognitive status (e.g., diabetes distress, depression, anxiety, delirium, dementia) • substance use disorders (e.g., tobacco, alcohol, marijuana) • spiritual care support(s)
Patient behaviour	• ability to adhere to co-created treatment plan • occupation and lifestyle

The IWGDF provides an algorithm to support clinical decision making related to selecting a proper offloading modality.[1] See Figure 10.

Figure 10: How to Select a Proper Offloading Modality

Diabetic foot ulcer (DFU) location

Non-plantar DFU

Proper modality:
- Removable ankle-high device
- Footwear modification
- Toe spacers or orthoses

Plantar forefoot or midfoot DFU

Is ischemia or infection present?

Yes

Severity:
- **Mild** infection

OR
- **Mild** ischemia

Proper modality:
- Non-removable knee-high offloading device

Yes

Severity:
- **Mild** infection + **Mild** ischemia

OR
- **Moderate** infection

OR
- **Moderate** ischemia

Proper modality:
- Consider using a removable knee-high offloading device

Yes

Severity:
- **Moderate** infection + **Moderate** ischemia

OR
- **Severe** infection

OR
- **Severe** ischemia

Proper modality:
- Address the infection and/or ischemia and consider using a removable offloading intervention

No

Proper modality:
- Non-removable knee-high offloading device

If the above modality is contraindicated or not tolerated:

Proper modality:
- Consider using a removable knee-high offloading device

If the above modality is contraindicated or not tolerated:

Proper modality:
- Use a removable ankle-high offloading device

If the above devices are not available:

Proper modality:
- Consider using felted foam with appropriately fitting footwear

If ulcer fails to heal:

Proper modality:
- Consider a surgical offloading intervention after reassessment of vascular status

Plantar Heel DFU

Proper modality:
- Consider using a removable knee-high offloading device

Permission granted from D-Foot International.

Hospitalization of patients with severe infection or moderate infection with other complicated issues may be required. See Table 11 for factors that should lead to considering hospitalization of the patient.

Table 11: Factors that Lead to Considering Hospitalization[1]

Factors that should lead to considering hospitalization[1]
• Severe infection (see findings suggesting a more serious diabetes-related foot infection above)
• Metabolic or hemodynamic instability
• Intravenous therapy needed (and not available/appropriate as an outpatient)
• Diagnostic tests needed that are not available as an outpatient
• Severe foot ischemia is present
• Surgical procedures (more than minor) required
• Failure of outpatient management
• Need for more complex dressing changes than patient/care partners can provide
• Need for careful, continuous observation

Psychological support

Diabetes and psychological issues are well documented. Co-occuring conditions such as diabetes distress,[129,135] depression, anxiety and sleep disorders require assessment, treatment and appropriate, timely interventions.[149,150] The complexity of living with diabetes contributes to changes in cognitive functioning in, "multiple domains such as attention, concentration, memory, executive function, and information processing speed".[150] This may be evident when persons with diabetes do not appear to engage in co-creating and updating care plans or education opportunities.

Clinicians need to screen for risk of mental health conditions and make timely referrals to health-care professionals trained in interventions. Treatment and intervention options may include the following: support to facilitate adaptation to diabetes, reduction of diabetes-related distress to improve outcomes, motivational interventions, stress-management strategies, coping skills training, family therapy and collaborative case management. Employment may be impacted, and the patient may need employment modification or time off, or to modify employment activities to support wound healing.[151]

Cognitive behaviour therapy and/or antidepressant medications may also be effective.[28] As well, it is important for persons and their care partners to collaboratively and proactively communicate with their pharmacist to optimize medication use.[152] Individuals taking psychiatric medications, particularly atypical antipsychotics, benefit from regular screening of metabolic parameters.[28] Self-management issues can be addressed in a one-on-one session or during diabetes self-management workshops given by peer leaders with diabetes.

Nutritional support

Clinicians can refer patients to credible resources to assist in decision-making regarding nutritional choices.[153] Nutrition recommendations for people with diabetes and foot ulcers should be individualized, taking into consideration co-morbidities, any previously documented abnormal laboratory test results, patient age, preferences, goals and medications.

Patients should be counselled regularly across the disease continuum by a registered dietitian[154] in a group or individually, preferably with their care partners present. It has been demonstrated that when dietitians collaborate with the patient in a meaningful exchange of information, A1c, quality of life and medication adherence is improved.

For more on nutrition and wound prevention and healing, please see Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview[24] and resources on the Wounds Canada website: https://www.woundscanada.ca/health-care-professional/resources-health-care-pros/nutrition

Physical activity and exercise

Improved pressure management can be facilitated through patient participation in appropriate activities. Low-impact activities such as swimming, aqua-fit classes and bicycling are preferable to high-impact activities such as walking, jogging and aerobics.

Diabetes Canada states at least 150 minutes of exercise per week (aerobic) and at least two sessions per week of resistance exercise are recommended, though smaller amounts of activity still provide some health benefits. Appropriate levels of physical activity alongside healthy nutrition plans should be a cornerstone to promote skin health and wound healing.[28] Most people with diabetes, or those at risk for diabetes, do not meet the Diabetes Canada's guidelines for aerobic and resistance exercise, despite the following:

- patients have the power to improve their blood glucose control by actively exercising five days a week and engaging in resistance training and
- regular physical activity, in conjunction with healthy eating and weight control, can reduce diabetes incidence by 60%.[28]

Therefore, it is essential that physical activity be built into the plan of care for most patients. Aerobic and resistance (weights, weight machines) training are recommended.[153] Fitness level is one of the strongest predictors of all-cause mortality in people with diabetes. Poor physical fitness is as strong a risk factor for mortality as smoking.

Threatening Ischemia

The IWGDF guidelines highlight the increased risk of major limb amputation in patients with both diabetes and PAD, especially in the presence of infection. It is important that clinicians understand that the inflammatory response induced by infection results in fluid accumulation that causes pressure in the tissues that may further compromise perfusion. The guidelines emphasize the need for emergency/urgent treatment when these factors are present, underscoring the importance of optimizing vascular perfusion for diabetic patients with foot ulcers through a comprehensive vascular assessment and, if necessary, surgical consultation.[1]

For additional information see Chapter 10: Best Practice Recommendations for the Prevention and Management of Peripheral Arterial Ulcers.

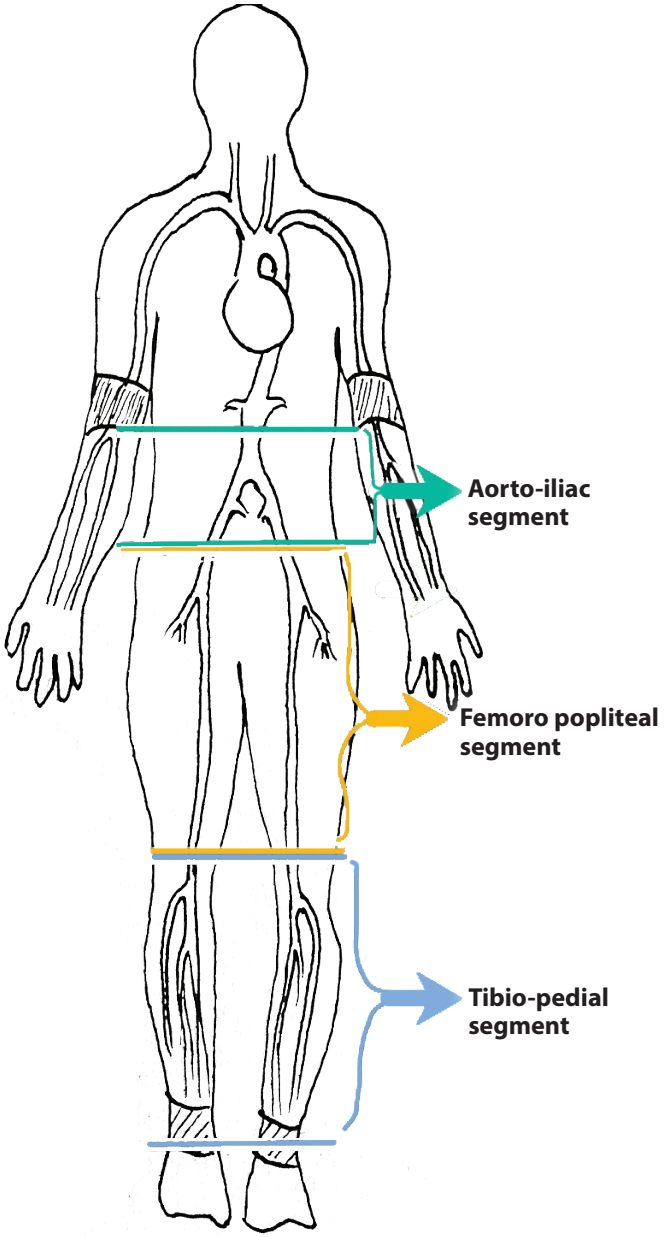
The most severe form of PAD is called chronic limb-threatening ischemia (CLTI). The term *CLTI* is preferred over *critical limb ischemia,* as the latter implies threshold values of impaired perfusion rather than a continuum. CLTI is a clinical syndrome defined by the presence of PAD in combination with pain at rest, gangrene or a lower limb ulceration over two weeks' duration.[155] Of concern is the presence of diabetes mellitus, as it increases the incidence of PAD, accelerates disease progression and worsens patient healing and overall outcomes.[156]

The IWGDF points out the significant negative impact of lower extremity ischemia on foot ulcer healing and stresses the importance of managing the increased cardiovascular risk associated with PAD. For patients presenting with specific diagnostic thresholds indicating severe ischemia, such as ankle pressure below 50 mmHg, ABPI less than 0.4, toe pressure below 30 mmHg, or $TcPO_2$ under 25 mmHg, immediate vascular imaging is advised to evaluate the need for revascularization.[1]

Revascularization is also considered for patients with significant tissue loss or infection, and when ulcers do not show healing within four to six weeks of optimal management. Before any major amputation, evaluating revascularization options to restore flow to foot arteries is essential, based on individual patient factors and local expertise. The effectiveness of revascularization should be objectively assessed post-procedure.

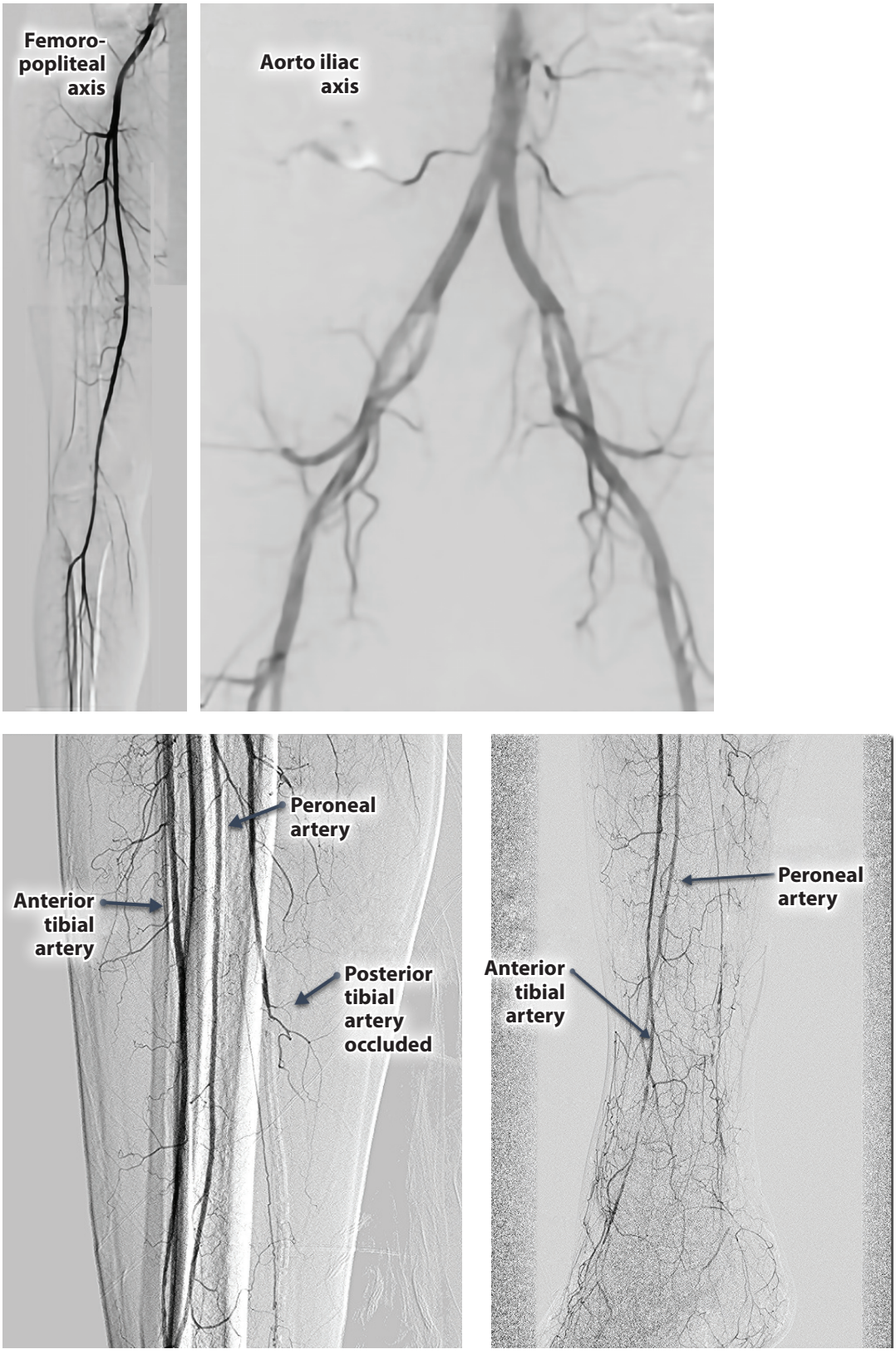
PAD is described anatomically by the level, or the arterial segment affected: aorto-iliac (AI) femoropopliteal (FP) or tibial/tibiopedial) (TBP).[157]

Figure 11: PAD Description. These descriptors are useful and are associated with clinical scenarios. For example, in smokers, atheromatous disease occurs more frequently in the AI and FP segments, whereas in individuals with diabetes, atheromatous disease involves the FP and TBP segments.



Permission from: Reeves I, Chaplain V, editors. Pratiques exemplaires en soins des plaies: de novice à expert. Presses de l'Université Laval; 2023.

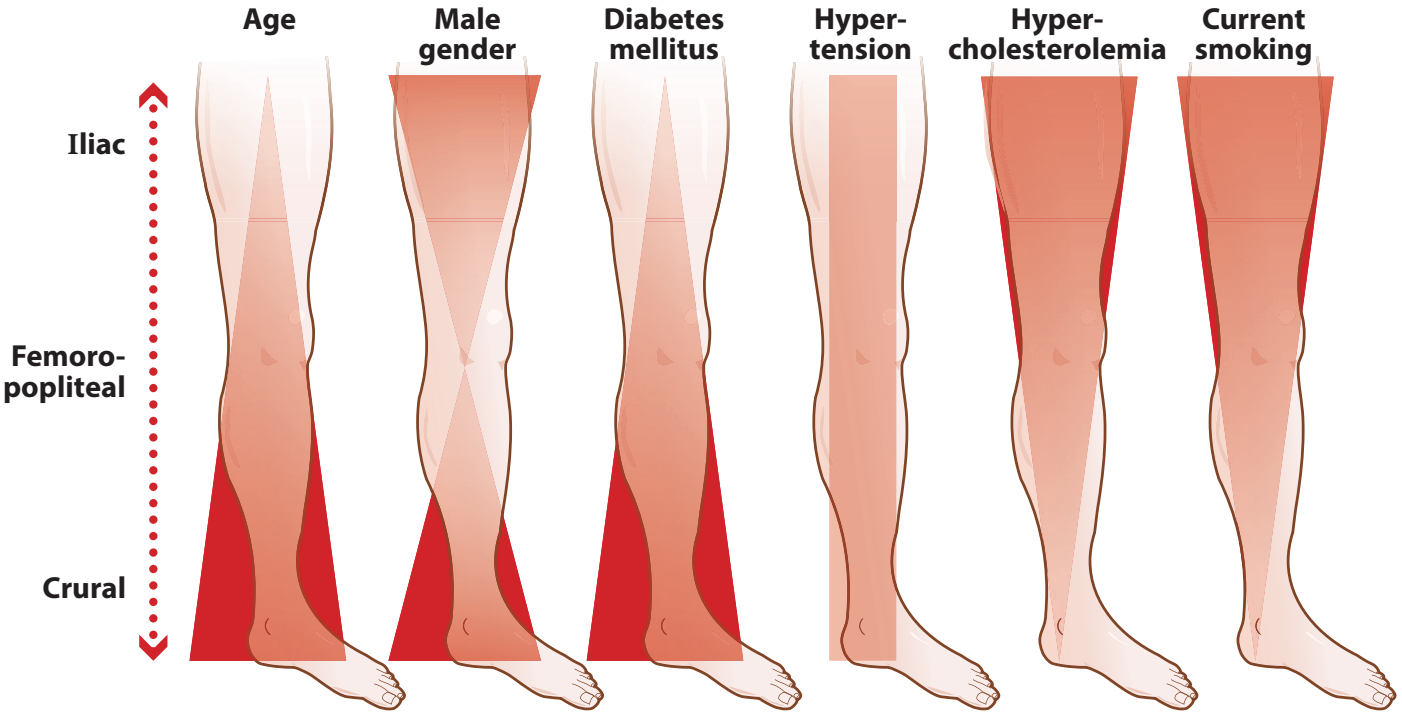
Figure 12: Example of an angiography in a patient with very distal peripheral arterial disease. In this case, the aorto-iliac and femoropopliteal axes are normal; however, only the anterior tibial artery and a portion of the peroneal artery are visualized. The vascularization of the foot is severely compromised.



Permission from: Reeves I, Chaplain V, editors. Pratiques exemplaires en soins des plaies: de novice à expert. Presses de l'Université Laval; 2023.

Patients with typical calf claudication usually present with disease in either the AI or FP segments, and often with only one arterial segment involved. In contrast, patients with severe arterial disease or critical ischemia will usually have two arterial segments involved of the three possible segments (AI, FP and TBP). Occasionally, only the TBP segment is severely affected, resulting in severe arterial disease or CLTI. This latter situation is more frequent in individuals with diabetes. Diehm et al. examined 2659 arteriograms of patients undergoing endovascular intervention. The AI disease was associated with younger age, cigarette smoking and male gender, whereas infragenicular disease was associated with diabetes and advanced age.[158] See Figure 13.

Figure 13: Association of Risk Factors with the Level of Atherosclerotic Target Lesions.
Red overlay on the anatomic figure illustrates the association of risk factor with pattern of atherosclerotic lesions.



Adapted from: Diehm N, Shang A, Silvestro A, Do DD, Dick F, Schmidli J, Mahler F, Baumgartner I. Association of cardiovascular risk factors with pattern of lower limb atherosclerosis in 2659 patients undergoing angioplasty. Eur J Vasc Endovasc Surg. 2006 Jan;31(1):59-63.

MVAP affects the iliac and femoral arteries with the same incidence in all patients, with diabetes or not. However, in individuals with diabetes, PAD occurs more frequently at the level below the knees, i.e., in the tibial arteries (anterior tibial, posterior tibial and peroneal arteries).[159] These arteries, although small, can be dilated percutaneously with balloons or perfused through a bypass surgery with good results. Pedal arteries have also been the target of revascularization. Small-vessel (microvascular) disease involvement is well described in the pathophysiology of other organs, such as the kidneys, heart, retina and peripheral nerves, but it does not affect the small arteries of the lower limb located distal to the tibial vessels, and certainly no more so than in a patient without diabetes but with PAD.[160,161] Capillary microangiopathy around nerves could, however, be one of the causes of peripheral neuropathy, but not of a decrease in peripheral tissue perfusion.[162,163]

For revascularization of the lower limb, procedures are classified according to their effect on blood flow: inflow or outflow. The disease involving inflow affects the aorta as well as the common, external and internal iliac arteries. The common femoral artery marks the transition point between inflow and outflow. Inflow interventions may include angioplasties with or without stenting, endarterectomies, and bypass surgeries. Disease affecting outflow involves stenosis or occlusion of the common femoral and its distal branches. The common femoral gives rise to two branches: the deep femoral and the superficial femoral. The superficial femoral artery becomes the popliteal artery at the knee, giving rise to the three tibial arteries (below the knee). Outflow interventions range from dilatations with or without stenting, to open angioplasty (with patch on the artery) or to bypass surgery using vein or synthetic conduits.

The primary aim of treatment for chronic critical ischemia is to reduce pain, prevent amputations and improve the patient's quality of life, including healing of arterial ulcers. To achieve this goal, many patients will require a revascularization procedure and an aggressive care plan to control cardiovascular risk factors. Occasionally, revascularization may not improve the patient's overall condition or mobility, and in certain circumstances, the risk-benefit ratio for the probability of success of the intervention is clearly unfavourable. This may happen if there is no realistic chance of healing or in a situation with a very large area of tissue destruction. When a functional foot is unlikely to be achieved, or if the patient is in a non-ambulatory state prior to the development of chronic critical ischemia, or if severe comorbidities can lead to poor prognosis, revascularization may not be in the best interest of the patient. Very frail patients with very short life expectancy, patients with poor functional status or patients with severe cognitive impairment may not be suitable for revascularization. Some situations will favour an arterial inflow procedure to improve the likelihood of healing a major limb amputation (below or above knee). The decision to adopt a palliative approach or proceed with a major amputation should be made in agreement with the person and their family and should involve a multidisciplinary team.[163,166]

Endovascular Treatment

Percutaneous endovascular treatment of arterial stenosis is a technique allowing balloon dilatation (or angioplasty) of arteries through a wire. The common femoral artery is punctured and percutaneous access to the vessel is established by working through valve introducer catheters. A wire is placed within the artery beyond the target lesion and then the inserted balloon is expanded with appropriate pressure. That leads to fracture of the lesion and stretching of the arterial wall. The evolution of endovascular therapy has introduced new technologies, including drug-eluting stents, self-expanding stents and cutting balloons (CBs).[164] These reduce post-treatment cell proliferation or restenosis, thereby improving patency. Pharmacologic treatment after angioplasty also has a role in preventing restenosis.

The endovascular approach is less invasive and therefore incurs less morbidity and mortality in the short term then an open surgical approach. On the other hand, it is less durable than the open approach.[165]

For short-distance stenoses in large vessels, the endovascular approach is excellent, with patency rates of 85% for common iliac and of 70% for external iliac at five years.[81,166]

Both the American College of Cardiology/American Heart Association (ACC/AHA) 2022 guidelines[164] and the European Society of Cardiology/European Society for Vascular Surgery (ESC/ESVS) 2017 guidelines[81] agree that hemodynamically significant upper inflow disease (aortoiliac) should be approached via an endovascular treatment if possible. In the case of outflow, they agree that endovascular and surgical revascularization procedures achieve similar outcomes.[167] However, the recent BEST-CLI trial may eventually influence these guidelines.[168]

Compared with the iliac angioplasties, the results of the superficial femoral arteries or popliteal arteries angioplasties are not as good and depending on the device (simple balloon angioplasty, drug-eluding angioplasty, drug-eluting stents, self-expanding stents), the permeability will vary but ranges from 50 to 70% at one year.[166] In fact, every three, six or twelve months, depending on the location and extent of the revascularization, radiological monitoring with ultrasound Doppler is needed to ensure vessel permeability and identify the appearance of early restenosis. As mentioned, the morbidity and mortality associated with endovascular procedures are low, such that multiple re-interventions,which may be required to keep the arterial tree open, are generally safe.[165]

Open surgical revascularization

Endarterectomy is a technique where atheromatous plaque is removed from the artery. The vessel is then often closed with a vein or prosthetic patch angioplasty to increase the diameter of the artery. Any specific artery can be treated with an endarterectomy if the lesion is localized to a segment of artery. The common femoral artery, the junction point between inflow and outflow, is the most frequent site treated with endarterectomy alone or in conjunction with a femoropopliteal bypass or an angioplasty of the proximal vessels (aortoiliac).

Aortoiliac (inflow) disease can be treated surgically with prosthetic bypasses, and they are associated with good patency rates (90% at five year for aortofemoral bypass).[169] Other types of bypasses called extra anatomical bypasses have lower but acceptable patencies (five years) such as femoral femoral bypasses (60-80%) or axillofemoral bypasses (80%),[170] and they are performed in situations when an aortofemoral bypass and an endovascular approach is impossi-

ble. All bypasses are associated with low but significant risk of perioperative wounds and grafts complication (hemorrhage and infection), some of which are avoided with endovascular approach.

The aortoiliac disease is generally treated with an endovascular technique with a stent but, when not possible, then a surgical bypass can be considered in patients with acceptable risks.[164]

Infrainguinal (ouflow) disease can be treated with a bypass originating in the common femoral artery and terminating in the popliteal artery above or below the knee, or even terminating in the tibial vessels or pedal vessels. These bypasses will be considered when one faces long segment occlusions that cannot be treated with an endovascular approach. The use of the saphenous vein is preferred, and the patency rate ranges from 60 to 80% at five years.[171] The more distal the bypass is taken the more the patency decreases.

Hybrid procedures

Hybrid procedures involve simultaneous use of surgery and endovascular techniques for revascularization. Often an endarterectomy and angioplasty of the common femoral artery will be combined with an endovascular angioplasty of the iliac vessels. This allows a more complete revascularization while optimizing the surgical time.

The choice of either endovascular, surgery or hybrid procedure depends on the patient anatomy and takes into consideration the feasibility and long-term durability of the procedure.

The choice of a revascularization procedure, either endovascular or open surgery, will be dictated by the location and distribution of arterial disease as well as the patient's comorbidities.[172]

To choose the best intervention, we must weigh the risk of the intervention against the benefit expected and the outcome of the intervention. The risks of the procedure must be low and the expected chances of revascularization high, restoring blood flow resulting in wound healing.

Chronic critical ischemia as opposed to claudication will often result in several segments of the arterial system involved—for example, an occlusion of inflow in the common or external iliac artery and a severe stenosis of the superficial femoral. Often an intervention on the inflow will be planned first. Following this, and depending on the importance of the outflow disease, an angioplasty of the superficial and popliteal arteries or a surgical bypass may be necessary to improve peripheral perfusion and heal an ulcer.

In a person with diabetes, PAD and a foot ulcer with an adequate segment of saphenous vein in whom infrainguinal revascularization is indicated and who would be suitable for both approaches, consider bypass in preference to endovascular therapy. Many studies identified in the systematic review on bypass surgery vs. endovascular therapy are observational and retrospective case reports.[173] The BEST-CLI trial is a large RCT comparing endovascular therapy first to open bypass surgery first. In the surgery group there are two parallel cohorts of patients: cohort 1 had a good segment of saphenous vein available for bypass and cohort 2 did not have a saphenous vein and required an alternate conduit.[173] The primary outcome was above-ankle amputation, or major reintervention, or death. Treatment with the GSV bypass surgery first was superior to endovascular therapy first for the primary outcome ($p<0,001$). In cohort 2 the primary outcome was similar between the two groups. 71% of patients in this trial were persons with diabetes.

Revascularization procedures should aim to restore in line blood flow to at least one of the foot arteries. Bypass surgery or endovascular angioplasty is ideally performed to an outflow vessel running into the foot. Pedal arch patency has been associated with improved wound healing and reduced risk of major amputation.[174]

Lower-limb Amputation

The decision to preserve or amputate a person's limb or foot is a difficult conversation to have with a patient, care partners and family members. Determining whether to amputate or not must be made on an individual basis and in discussion with care partners and family. It requires an in-depth evaluation of each patient's physical status, mental health, spiritual and cultural beliefs and socio-economic status. While amputation is often seen as the last resort and can elicit a sense of failure for both the patient and the clinician, for some it can be life-giving when there is sepsis from limb infections that would otherwise lead to death. For some it may be a relief from intractable odour, the burden of dressings and living with ischemic pain. Support of the individual and care partners pre- and post amputation is important and must be planned for the long term to support adaptation and increase coping skills.

The World Health Organization has stated that prostheses (artificial hands, legs) and orthoses (splints, braces) enable individuals to live healthier, dignified, more independent lives[175] and that prosthetics and orthotic services play a role in prevention and treatment of diabetes-related foot ulcers. When a limb is amputated, a prosthesis is offered. Yet, it is important to note that not all patients access or use prosthetics. Prosthetic candidacy is dependent upon strength, fitness, range of motion, skin integrity, cognition, functional goals and the level of the amputation. Though prosthetics can offer many benefits, abandonment of the prosthetics does occur.[176]

Post-amputation care is essential for health, function and mobility. With all lower-limb amputations, the use of compression in the form of compression socks, tubular bandages, elastic wrapping (not for above knee amputations) is essential to help shape the remaining limb—often to prepare the stump for a prosthetic or to reduce edema to promote wound healing.[177] Consideration needs to be given to stump edema and wound, periwound skin and prosthetic care for the prevention of further skin breakdown. The Canadian War Amps website provides tips to identify and correct minor problems.

Although not everyone will benefit from the provision of a lower-limb prosthesis and not all will master their device, patients should be offered this option.[178] Individuals living with diabetes and lower-limb amputation, and their care partners, should be encouraged to take ownership of their health and be introduced or reintroduced to foot-care strategies if there is a remaining limb. In one study, it was found that almost half of those living with diabetes who were admitted to an inpatient amputee rehabilitation program had never received information on preventative foot care.[179] Hopping on the remaining limb post operatively will increase plantar pressures and should be done cautiously and in consideration of the presence and severity of neuropathy. It should never be done in the presence of an actual or suspected Charcot deformity. Where there is significant loss of protective sensation and/or Charcot foot, safe transfers should be the main goal until prosthetic training is provided.

When contemplating a major amputation (above the ankle), it is advisable to explore the possibility of revascularization as a first option. The primary objective of revascularization is to restore inline flow to at least one foot artery, preferably the one supplying the wound's anatomical region.[1]

Lower-limb Amputation

The criteria to amputate can be:[180,181]

- clinical: peripheral arterial disease, tissue viability, progressing infection (sepsis)
- patient-focused: lifestyle, occupation, age, preferences, attitude, reliability, social support system, access to care, financial resources
- clinician-focused: policy and procedures, education, advanced skin and wound care system: regional/institutional policies may be in place to support or inhibit limb preservation versus amputation

Amputations can be divided into two broad categories.
Minor amputations:

- amputation of digits
- partial foot amputation
- ankle disarticulation

Major amputations:

- below-knee amputation, abbreviated as BKA
- knee disarticulation
- above-knee amputation, abbreviated as AKA (transfemoral)
- Van Nes rotation/rotationplasty (foot turned around and reattached to allow the ankle joint to be used as a knee)
- hip disarticulation
- hemipelvectomy/hindquarter amputation

4.2 Optimize the local wound environment

In the management and prevention of foot ulceration, treating the cause is crucial for devising effective treatment strategies and preventing recurrence.

Discussion: Local wound care needs to be based on healing potential and the goals that have been set by the patient and care partner as part of the team. The wound environment should be optimized. This involves cleansing, irrigation, debridement, ensuring bacterial balance and controlling moisture.

See Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview[24] for more on local wound care.

4.2.1 Cleansing

Discussion: Wound cleansing solutions vary and should be used at body temperature. Cleansing solutions should be nontoxic, hypoallergenic, readily available, cost-effective and easy to use. Wound cleansing solutions commonly used in management of diabetic foot ulcers include sterile normal saline, sterile water, potable tap water and liquid antiseptics.

See Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview[24] for details on cleansing the peri-ulcer and ulcer.

4.2.2 Debriding

Discussion: Debridement involves removing debris (biofilm), eschar and surrounding callus to promote wound healing. Debridement methods include sharp/surgical, mechanical, autolytic and biologic (larval) therapies.

Persons with diabetic ulcers are prone to heavy peri-ulcer callus development. Sharp surgical debridement is considered the gold standard for DFUs.[1] Debridement allows the clinician to do the following:[102]

- remove tissue that serves as a reservoir for bacteria
- disrupt surface biofilm
- appreciate the depth of the ulcer and evaluate for possible bony involvement
- reduce peak plantar pressure caused by calluses
- facilitate the collection of specimens for culture.

Sharp debridement using a scalpel or curette is considered the optimum method for rapidly debriding the wound.[102] However, only health-care professionals with the appropriate level of training (education, knowledge, skill, attitude and mentorship) should perform sharp or surgical debridement.[102,182] If there is inadequate blood supply to the wound, sharp debridement is contraindicated. Due to the presence of peripheral neuropathy, this is usually a painless procedure; however, pain may limit debridement in some patients. Evidence exists to support regular serial debridement of diabetic foot ulcers to improve healing rates.[102,182] The frequency of debridement depends on the needs of the individual patient.

See Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview[24] for specifics on debridement.

4.2.3 Managing bacterial balance

Discussion: Diabetic foot infections are common, and a comprehensive approach is required for the diagnosis, management and prevention of future events. Diagnosis is made on the basis of clinical symptoms and signs, with adjunctive microbiologic testing to guide therapeutic decisions. Once identified, the infection should be classified by severity. (See Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview[24]).

To manage diabetic foot infections, clinicians are advised to follow these steps:

1. Evaluate signs and symptoms
2. Obtain appropriate specimens for culture
3. Select appropriate antibiotics (based on local epidemiology and antibiotic susceptibility patterns)
4. Determine effectiveness of antibiotics
5. Facilitate further testing
6. Refer to other specialties.

Antibiotic Selection

Antibiotic selection should be empiric and initially related to patient factors and the severity of the infection. In general, acute diabetic foot infections without prior antibiotic treatment are caused by aerobic Gram-positive organisms and most commonly by *Staphylococcus aureus* (including methicillin-resistant strains), alone or in conjunction with the β-haemolytic streptococci.[28] With time, the microbiology of the wound becomes polymicrobial and includes anaerobes. For more severe infections, the recommendation is to use antibiotics with broad-spectrum coverage until culture results and clinical response can be evaluated. Coverage for methicillin-resistant organisms (MRSA) should be considered based on local epidemiology and risk factors. The duration of therapy depends on the severity of infection, the involvement of bone and the patient's response to treatment.

In general, for mild soft tissue infections, one to two weeks of oral treatment is recommended.[77,102,183] For more severe soft-tissue infection or for larger necrotic wounds, a longer course may be required (three to four weeks).[183]

Osteomyelitis usually requires six weeks of treatment, which may be delivered orally or parenterally or combined parenteral and oral, based upon the patient's clinical presentation. Surgical consultation may be required.[102] Antibiotics should be discontinued with resolution of infection, which may be determined on the basis of clinical, biochemical and/or radiographic features, and are not required to continue until wound closure.[102] Following surgical management of osteomyelitis, consider three weeks of antibiotic therapy for minor amputations.[1] It is considered prudent to follow patients after treatment of osteomyelitis for six months to ensure resolution.

Empiric antibiotic options used to treat diabetic foot infections are listed in Table 12.

This serves as a guide only, and antibiotic decisions must be based on the type and severity of infection, culture result if available and patient factors such as comorbidities, allergies and drug interactions (sensitivities) along with local epidemiology and resistance patterns. Consultation with an infectious disease specialist may be required.

Table 12: Empiric Antibiotic Choice for Patients with Diabetic Foot Infections[1]

Severity of infection	Target Bacteria and Examples of Antibiotic Choices & Scenarios (Classes of antibiotic examples in notes below)	
Mild Treatment duration: 1–2 weeks	**Gram positive cocci: S. aureus, beta-hemolytic streptococci**	cephalexin[c], cloxicillin[g]
	Beta-lactam allergy	clindamycin, moxifloxacin[j], levofloxacin[j], trimethoprim-sulfamethoazole, doxycycline
	Gram positive cocci and Gram-negative rods – if recent antibiotic exposure	amoxicillin/clavulanate[b], ampicillin/sulbactam[b], trimethoprim-sulfamethoazole, levofloxacin[j], moxifloxacin[j].
	High risk for MRSA	trimethoprim-sulfamethoxazole, clindamycin, doxycycline, levofloxacin[j], moxifloxacin[j] (depends on sensitivities), linezolid
Moderate to Severe Treatment duration: 3–4 weeks; osteomyelitis: 6 weeks Oral antibiotic should not be used with severe infection, except to switch once infection has improved. Consider consult with infectious disease specialist Urgent surgical and vascular consult should be considered	**No complicating features: Gram positve cocci +/– Gram negative rods**	amoxicillin/clavulanate[b], ampicillin/sulbactam[b], cefuroxime, cefotaxime, ceftriaxone
	Recent antibiotic exposure: Gram positve cocci +/– Gram negative rods	Ticarcillin/clavulanate, pipercillin/tazobactam, cefuroxime[f], cefotaxime[d], ceftriaxone[e], ertapenem[h]
	Macerated ulcer or warm climate	Gram negative rods including Pseudomonas sp: Pipercillin/tazobactam[k], ticarcillin/clavulanate[k], Cloxicillin[g] + Ceftazidime or ciprofloxicin, meropenum[i] or imipenem[i]
	Ischemic/ Necrosis/ Gas forming: Gram positive cocci +/– Gram negative rods +/– strict anaerobes	amoxicillin/clavulanate[b], ampicillin/sulbactam[b], ticarcillin/clavulanate[k], pipercillin/tazobactam[k], ertapenem[h], meropenem[i], imipenem[i] Cefuroxime[f] or cefotaxime[d] or ceftriaxone[e] + clindamycin or metronidazole.
	MRSA risk – add or substitutes	vancomycin[l], linezolid, daptomycin, fusidic acid, trimethoprim-sulfamethoxazole, doxycycline, daptomycin
	Risk factors for resistant Gram negative rods: Extended-spectrum beta-lactamase	ertapenem[h], imipenem[i], meropenem[i], ciprofloxicin[j], amikacin[a], colistin.

Classes of antibiotics listed above:

a. Amikacin – aminoglycoside
b. Amoxicillin/clavulanate, ampicillin/sulbactam(not available in Canada) -ß-lactam-ß-lactamase inhibitor
c. Cephalexin – 1st generation cephalosporin
d. Cefotaxime -3rd generation cephalosporin(not available in Canada)
e. Ceftriaxone -3rd generation cephalosporin (only for iv use)
f. Cefuroxime -2nd generation cephalosporin
g. Cloxicillin – semisynthetic penicillinase-resistant penicillin
h. Ertapenum – group 1 carbapenem
i. Meropenem, imipenem - group 2 carbapenem
j. Moxifloxacin/Levofloxacin, ciprofloxicin – flouroquinolones
k. Pipercillin/tazobactam, ticarcillin/clavulanate - ß-lactam-ß-lactamase inhibitor 2
l. Vancomycin – glycopeptide

MRSA – methicillin-resistant Staphyloccus aureus (risk factors are
ESBL – extended-spectrum ß-lactamase

Adapted from the IWGDF, 2023[1]

Additional considerations

An integrated team approach is recommended for the treatment of complicated infections.[25,28,120] Assessment and appropriate referral to consultants in infectious diseases, and vascular surgery should be initiated early. Similarly, orthopedic surgery, plastic surgery or podiatry/chiropody should be involved to manage foot deformities, resect infected bone or surgically debride tissue. It is often necessary to consult with endocrinology and, certainly, pressure-offloading experts. Close clinical reassessment and follow up is required.

See Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview[24] for a general discussion on managing bacterial balance.

4.2.4 Managing moisture balance

Discussion: Ensure optimal local wound moisture balance to promote healing by choosing an appropriate dressing for the different phases of wound healing.[25] Appropriate wound care and dressing selection promote healing and reduce the risk of infection, so selecting the most appropriate dressing, at a frequency aimed at preventing periwound skin irritation and maceration while keeping the wound bed moist, is essential in managing moisture balance.[105,120]

See Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview[24] for more on managing moisture balance in wounds.

4.3 Select the appropriate dressings and/or advanced therapy

Discussion: The dressings selected may have a considerable effect on the outcome of a diabetic foot ulcer. However, there is insufficient evidence to recommend a specific dressing type for diabetic foot ulcers[184-187]

The general principles of wound management involve the provision of a moist wound environment, debridement of nonviable tissue (nonischemic wounds) and offloading of pressure areas.[28] It cannot be overstated that, for uncomplicated diabetic foot ulcers, dressing choice should always be secondary to correcting high plantar pressures and preventing repetitive trauma.[188] Dressings, however, are required to adequately manage moisture, minimize the risk of infection,[189,190] manage shear forces,[191] and help maintain optimal wound temperature.[192] Choice of dressing should be based on these factors as well as cost and patient preferences. It is important that clinicians and patients jointly select the right dressing and therapies after following the previous steps in the Wound Prevention and Management Cycle.

Specifically, one should consider that dressings with increased bulk may increase plantar pressures over the wound itself or on the contralateral plantar surface.[193,194] Although thicker dressings may initially be considered to pad the wound and protect it from trauma, the opposite is more likely to be true if, in fact, the thicker dressing decreases the space for the foot in the patient's shoe or offloading device. Although dressings can significantly reduce tissue shear forces, there is insufficient published data to assess one dressing's potential over another in reducing shear.[195] Instead, the clinician is left to clinically evaluate shear force reduction by looking for increased callusing of the periwound skin or by evaluating the presence of sub-keratotic hematoma or hemorrhage.[196]

Because of their plantar location, dressings generally are at high risk of saturation due to sweating or external moisture sources such as daily showering or bathing. For patients who prefer self-managed care, a simple non-adhesive dressing that can be changed daily is supported by the literature as a means of managing the moisture balance in the wound and increasing patient adherence to therapy.[197] The ongoing active treatment of diabetic foot ulcers and the presence of a dressing do not negate the need for daily foot inspection.

For further information on dressings, see See Chapter 4: Best Practice Recommendations for the Prevention and Management of Wounds: An Overview[24] and the Wounds Canada Product Pickers: Wound Dressing Formulary and Wound Dressing Selection Guide.

Caution: Moist wound healing is a relative contraindication for ischemic ulcers. Consider any of the following adjunctive treatments in non-infected ulcers that fail to heal after four to six weeks despite optimal clinical care:

- A sucrose octasulfate impregnated dressing in neuro-ischemic ulcers (without severe ischemia)
- A multi-layered patch of autologous leukocytes, platelets and fibrin in ulcers with or without moderate ischemia
- Placental membrane allografts in ulcers with or without moderate ischemia
- Topical oxygen therapy
- Systemic hyperbaric oxygen therapy as an adjunctive treatment in ischemic ulcers
- Negative pressure wound therapy to help heal post-operative wounds.[1]

Dressing Protocol for Diabetic Foot Ulcers[184-187]

Prior to dressing/therapy selection the clinician needs to consider three components of care. First, whether best practice has been implemented, including the reduction of plantar pressures, management of blood glucose, control of arterial perfusion and infection, assessment of mental health and wellness, consideration of care partner, family and social supports and availability of funding for therapy. While selecting a dressing the clinician should also consider specific needs of the wound, including necrotic tissue and bacterial and moisture balance. Finally, the goals of care, such as wound healing, wound closure, pain management, exudate management, quality-of-life improvement and/or cost-effectiveness should be considered.

Once the dressing is selected, the clinician should plan the length of trial of the dressing/therapy and ensure it remains part of the assessment, treatment and evaluation processes.

For non-healing ulcers despite optimal care, adjunctive treatments such as sucrose octasulfate dressings for neuro-ischemic ulcers, multi-layered patches of autologous cells, placental membrane allografts and topical and systemic hyperbaric oxygen therapy may be considered, based on the ulcer's ischemic status and available resources. Conversely, the use of biologically active products, topical antiseptics and antimicrobial dressings lacks strong support for routine management.[1]

The following treatments are not well-supported for routine ulcer management:

- biologically active products (collagen, growth factors, bio-engineered tissue) in neuropathic ulcers; topical antiseptics and antimicrobial dressings or applications.[1]

4.4 Engage the team to ensure consistent implementation of the plan of care

Discussion: There is a need to acknowledge the ongoing and potentially escalating risk for skin breakdown in individuals with diabetes as well as the chronic nature of diabetic foot ulcers. Although individual ulcers may occur and reoccur, the relative risk for re-ulceration is high[198] and the team must understand that diabetic foot ulcers are a part of a chronic disease process that must be managed every day in the same way that blood sugars, blood pressures and mental health are managed. The patient's psychological adjustment to a chronic disease is important to disease outcomes, and the disease itself can challenge a patient's belief that they can live well with a chronic disease.[199] For some patients, psychological therapy may be required to support the consistent implementation of the elements of the care plan.

Diabetes-specific education and additional specialized training to help integrate new knowledge and transform old practices are essential for all team members. Investments must be made to ensure that health-care professionals receive specialized training in diabetes education and other chronic conditions relative to the population and cultural contexts in which they practise. In addition, patients, care partners and families need education on diabetes, mental health and wellbeing, preventative foot care, skin health and local wound care.[200]

Educational and academic institutions are encouraged to incorporate best practice guidelines and recommendations into undergraduate nursing, para-professional, medical and allied health-care professional (physical and occupational therapists, personal support workers, paramedics) curricula. These institutions also have an obligation to keep up to date with advances in diabetic foot skin health, promoting wound prevention, assessment and management strategies, and to develop standardized curricula to implement and evaluate these changes in practice settings.[25]

Key Interventions

- Support the patient and care partners in learning about skin health and prevention of foot complications. Engage in credible teaching websites such as: Wounds Canada. Do It Yourself (DIY) Skin Health Series. https://www.woundscanada.ca/patient-or-caregiv er/resources/diy-seriesWounds Canada. Care At Home Series. https://www.woundscanada.ca/patient-or-caregiver/resources/care-at-home-series
- Support the patient and care partners in learning about the chronic and complex nature of diabetic foot ulcers, including factors such as neuropathy, pressure, poor arterial flow and the implications of infection.
- Facilitate referral to mental health and well-being support resources and teams, including psychologist or social worker, and Indigenous support services as needed.
- Monitor high-risk patients.
- Support patient self-management to ensure daily foot examinations, appropriate footwear selection and use, injury recognition and accessing of the appropriate facility for care.

Patient and Care Partner Education

Patients with LOPS should be provided with education on ways to substitute other sensory modalities (palpation or visual inspection using an unbreakable mirror, hand-held thermometer) for surveillance of early foot problems.[70]

The IWGDF emphasizes the need for integrated teams to offer structured, organized and repetitive learning opportunities.[1] In recent Canadian studies, researchers noted that not all persons with diabetes attended education, were aware of credible resources or engaged their foot care partners in daily foot care.[95,201]

Specifically, the IWGDF reminds teams to provide education that focuses on self-care, increasing patients' knowledge and awareness and improved motivation to engage in protective behaviours.[1] They state patients at risk level 1 or higher should be taught to conduct daily foot exams and hygiene, and to identify early signs of pre-ulcerative issues (callus). Patients should learn how to protect skin, use emollients for dry skin and wear seasonally appropriate socks and footwear to protect their feet in all activities, both inside and outside.[1]

Teaching patients and care partners (if able) to trim and file nails has been demonstrated to promote discussions and engagement in self-care.[1]

Proactive education should be offered with the patient and care partner or in small groups. Education should be culturally sensitive, relevant and appropriate to the health literacy of the participants. Sessions should be repeated and creatively presented to better engage learners.[1]

Ensuring that the person with diabetes, and ideally their close family or caregivers, fully understands the information, is motivated to follow the guidance and possesses the necessary self-care skills is vital. Additionally, health-care providers should undergo regular training to enhance their proficiency in educating and caring for individuals at risk of foot ulceration.[1]

See more Canadian Wound Care Advocacy Resources at:

- Diabetes Advocacy. Diabetes Canada. (2023). Introducing diabetes advocacy. https://www.diabetes.ca/advocacy---policies/advocate-for-diabetes-canada
- Wounds Canada. (2023). Advocacy program. https://www.woundscanada.ca/leader-change-maker/11-patient-caregiver/8-advocacy-program
- Wounds Canada. (2023). Policy recommendations. https://www.woundscanada.ca/leader-change-maker/advocacy/policy-recommendations
- Registered Nurses' Association of Ontario. (RNAO, 2023). Policy and political action. https://rnao.ca/policy

Step 5: Evaluate Outcomes

Recommendations

5.1 Determine if the outcomes have met the goals of care

Discussion: Using validated and responsive skin and wound assessment tools and patient feedback, the clinician should determine if the goals of care have been met. Goals are patient-specific, may not involve complete closure of a

wound and may not be those the clinician would choose. If goals have been met, begin discharge planning by reviewing self-management strategies (see Section 5.3). If goals change, refer back to the Wound Prevention and Management Cycle to guide treatment based on new goals.

5.2 Reassess patient, wound, environment and system if goals are partially met or unmet

Discussion: If the goals are not met or only partially met, clinicians should re-evaluate the patient systemically. This includes general care such as blood glucose and A1c, blood pressure control, cholesterol, any medications that may impede healing, smoking cessation, exercise and healthy eating, mental health and wellness and engagement in screening for complications (lower limb, feet, heart, vision and renal).

Wound healing goals include measurement of wound progress, exudate, appearance, quality of life (suffering), undermining, and edge.[204] Paltry and colleagues demonstrated the, "best predictor of wound healing at three months was a 41.8% wound size reduction at four weeks".[205] If the wound is not healing, it requires a full reassessment to determine if all factors that affect healing have been managed. If healing still does not occur, a biopsy should be performed to rule out disease. If the wound is not healing at the expected rate, the clinician should consider the possibility of missed infection, vascular compromise, malignancy, inadequate offloading, lack of patient engagement in care or systemic, environmental or patient-centred obstacles to self-management (e.g., diabetes distress, anxiety, depression). According to the RNAO guidelines, these parameters can quickly change with a high risk of infection and amputation, so frequent monitoring is required.[25]

The most common reason for delayed healing is inadequate offloading.[25] Increasing evidence suggests that the majority of patients with diabetes are non-adherent to using offloading devices or footwear on a regular basis (NICE, 2023). In a study by Ababneh et al. (2023) patients with diabetic foot ulcers used the prescribed offloading treatment only 35% of the time during ambulation though they self-reported adherence of 90%.[206] To prevent and facilitate healing of foot ulcers, pressure redistribution must be addressed with an appropriate offloading device, use of technologies, and identification of barriers to patient adherence must be explored.

Table 13: Core Details for the Reporting of Intervention studies in the Management of Diabetic Foot Ulcer[207]

	Off-loading	Peripheral Artery Disease (PAD)	Infections
Population	No additional details	• Smoking status • Ambulatory status • Previous interventions for PAD, heart failure, cerebrovascular disease • Other relevant comorbidities (e.g., renal disease, depression) • Relevant cardiovascular drugs • Limb symptoms: none, atypical (weakness, limping), intermittent claudication, and rest pain • Toe systolic pressure, toe-brachial pressure index, or transcutaneous partial pressure of oxygen (TcPO2) • Arterial pulse waveform • Anatomical distribution of the vascular disease in the leg • Number of active ulcers • Site of index ulcer	• Preceding antimicrobial use (type, route, duration, and time before presentation) • Immunosuppression • Infection type (using Infections Disease Society of America (IDSA) or perfusion, extent, depth, infections, and sensation (PEDIS) grading: none, mild, moderate or severe • Involvement of bone or joint • Description of how samples were obtained for microbiological examination • Type of and results of microbiological examination (Gram stain and susceptibility)

cont'd. . . .

Interventions	• Details on non-surgical device, application method, material use and frequency of replacement • Specific design details of the foot-device interface • Person applying the device: the patient, a non-professional carer, or a health-care professional • Details of surgical intervention • Evidence of pressure-reducing efficacy if study is on plantar ulceration	No additional details	• Surgery undertaken before, or in association with, antimicrobial administration • Any other relevant intervention (including wound debridement, cleansing, and antiseptic use) undertaken before or in association with antimicrobial administration • Antimicrobial regime: route of delivery, agents and duration
Outcomes	• Ulcer healing • Adherence to the use of non-surgical removable interventions • Foot pressure (for footwear and surgical interventions) • Ambulatory activity level	• Number of participants alive with an intact foot • Description of outflow in the foot (in case of surgical or endovascular interventions) • Ulcer healing • Measures of the effectiveness of the vascular intervention (e.g., toe pressures and TcPO2) • Number of patients with minor and with major amputations	• Resolution of infection (which should be defined) at a prescribed time after stopping antimicrobial treatment • Clinical or laboratory signs of persistent infection at the end of antimicrobial treatment • Number and type of surgical procedures, including amputation (with level of amputation defined according to existing guideline) • Days of antimicrobial use, antimicrobial-free days, and days of hospital admission • Prevalence of antimicrobial resistance after treatment

5.3 Ensure sustainability to support prevention and reduce risk of recurrence

Discussion: One important component in sustainability is active patient engagement in managing their care and making choices that will optimize their health status. Studies evaluating diabetes-related education are growing. In a systematic review (14 studies) Abualula et al. discuss the importance of structured educational interventions with an indirect behavioural skills development in adolescents with type 1 diabetes may improve their quality of life.[206] Campbell et al. in a review (16 studies) focused on understanding the role of community health workers alongside diabetes specialities to promote better diabetes outcomes.[208] In an integrative review Colson et al. identified the need for more research to understand the effects of diabetes education for pediatric and adolescents.[209] Similarly, Drovandi et al. report the need for larger studies focused on evaluating the effectiveness of educational interventions focused on diabetic foot disease in adults. These researchers reported diabetes education programs increased diabetic foot disease knowledge and self-care behaviour scores.[210] In addition, the role of machine learning (ML) is growing in understanding the ML role in managing diabetic foot complications including to, "advance diagnostic accuracy and therapeutic approaches by leveraging developments in medical imaging, biomarker detection, and clinical biomechanics".[211]

Patients, care partners, and their families learn through different modalities partially due to learning styles, literacy, preferences (including technologies), and the individual's primary language. Written education material should be available in the relevant language and at a font size appropriate for the reader who may have impaired vision. The role of appropriate technologies in education is expanding. The importance of understanding the role of technology (phone, email, applications, artificial intelligence [AI]) is important when working with patients and their care partners.[212] There is a growing body of research exploring short messaging services[213] and technology that supports home foot monitoring.[214-216]

A role-modeling and real-life demonstration of recommended diabetic foot care techniques can have a positive influence in retention of information and does not require the ability to read.[179] Abrar et al. also remind us of the importance of culture and language.[217] In addition, a patient's trust in the deliverer of the information and the rapport established is also essential if education is to be effective.[216,218]

Whatever the method or methods used, patients should have the opportunity to take part in evidence-informed educational activities, including self-management programs that have specific aims and learning objectives, meet the needs of the patient and promote the patient's ability to manage their own health, if appropriate.[1,25,28] In addition to self-management, patients with diabetes need the continued support of their professional health-care team. An important component of this support is an annual foot inspection that includes monofilament testing, with more frequent testing if indicated by the results of a validated diabetic foot risk screening tool[1,25,28] as well as a foot inspection every time they visit their primary care provider.[1]

Conclusion

Promotion of foot health and prevention of foot complications must become a priority for diabetes care teams across all care settings.

For persons living with diabetes, and their care partners, the development of a diabetic foot ulcer can have devastating complications, multiple hospitalizations, strain on mental health and well-being, infection, amputation and even death. Therefore prevention should be the most important consideration for patients and health-care professionals on the team.

Patients and their care partners need regular, relevant information delivered using clear, effective communication techniques on how to protect their intact skin, prevent ulcers and care for wounds should they develop. They need routine reminders as to how to care for their feet, detect problems early and seek help in a timely manner when problems arise.[1,25,120,121]

If an ulcer develops, aggressive management involving a co-ordinated multidisciplinary team is required. Teams must recognize that the patient and their overall well-being are at the centre of care.

Moreover, integrated teams must recognize that their goals relate not only to management of the wound, but also to correction via the appropriate treatment pathway of the factors that have led, or may lead to, ulceration. Teams may then be successful at breaking the cycle of diabetic foot ulcer development and recurrence and thus preserve limbs.

Health-care organizations must support integrated teams to promote risk assessment and preventative strategies to prevent wounds and to promote wound healing when wounds do occur. This will reduce hospital admissions, infections, length of stay and amputations—thus reducing the financial and economic burden on health-care systems and improving the health outcomes and quality of life of patients.[1,28]

Developing and sustaining successful integrated teams that have a strong impact require standardized, relevant education, motivated health-care workers, supportive organizations and strong associations that engage community, regional, provincial/territorial and federal support.[25,28] The results will have not only a huge impact financially, but also socially, emotionally and psychologically for patients, care partners and their communities.

To diminish the detrimental consequences associated with diabetic foot complications, Canadians deserve an overall structure that is designed to meet the needs of patients requiring preventative and often chronic disease care, rather than simply responding to acute problems when they occur. Factors to consider include the following:

- well-defined treatment pathways and timely access to care in each community
- implementation of interprofessional guidelines for education, screening, risk reduction, treatment
- self-management education for patients care partners, family members
- establishment of services to detect individuals who are at risk, through annual foot examination of all patients and regular screening, with the frequency determined by level of risk
- universal preventative foot care services at the point of care for people living with diabetes
- public reimbursement for preventative footwear, socks and offloading devices for individuals who lack private insurance coverage

- establishment of integrated teams with specialized education to deliver timely and effective treatment if foot complications arise
- auditing of all aspects of the service to ensure that local practice meets accepted national and international standards of care.[1,25]

This chapter will serve as a guide to providing a systematic approach for the prevention and management of diabetic foot complications and assisting organizations in the successful development and implementation of programs to support patients and their teams.

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Appendix A: Patient Quality-of-Life Screening Tools

- The Problem Areas in Diabetes Scale (PAID).[1] http://care.diabetesjournals.org/content/20/5/760
- The Diabetes Distress Screening Scale.[2,3] www.diabetesed.net/page/_files/diabetes-distress.pdf
- The World Health Organization – WHO-5 Well-being Index.[4] www.ncbi.nlm.nih.gov/pubmed/11824831
- The Hospital Anxiety and Depression Scale (HADS).[5] https://academic.oup.com/occmed/article/64/5/393/1436876
- The Patient Health Questionnaire (PHQ-9).[6] https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/bc-guidelines/depression_patient_health_questionnaire.pdf
- The Center for Epidemiological Studies-Depression Scale (CES-D).[7] https://www.apa.org/pi/about/publications/caregivers/practice-settings/assessment/tools/depression-scale
- The Beck Depression Inventory.[8] www.hr.ucdavis.edu/asap/pdf_files/Beck_Depression_Inventory.pdf

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Appendix B: Care Partner Stress Screening Tools

- Kingston Caregiver Stress Scale (KCSS).[1] https://providencecare.ca/wp-content/uploads/2016/10/KCSS-Assessment-Form.pdf
- The University of Washington Center on Outcomes Research in Rehabilitation has developed several self-reported measures for consideration.[2] https://uwcorr.washington.edu/measures/
- University of Washington Caregiver Stress Scale
- University of Washington Caregiver Benefit Scale
- University of Washington Self Efficacy Scale (UW-SES)
- The Behavioral Diabetes Institute offers tools for caregivers of teens, adults and partners of adults with diabetes.[3] https://behavioraldiabetes.org/scales-and-measures/

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Appendix C: Quality-of-Life Tools and Scales for Persons Experiencing an Amputation and/or Prosthesis

- The Trinity Amputation and Prosthesis Experience Scale (TAPES-R) - Revised.[1] https://www.physio-pedia.com/images/e/e7/TAPES_2011_Sept_2011.pdf
- Amputee Mobility Predictor Assessment Tool - AMPnoPRO.[2] https://www.physio-pedia.com/images/f/fa/AmpNoPro.pdf
- Functional Assessment Questionnaire for Amputees (FMA).[3]

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Appendix D: Additional Information on Conducting Sensation Tests (SWMT)

Monofilament pressure testing is part of a comprehensive lower limb assessment to screen for loss of protective sensation (LOPS). The inability to perceive the monofilament force is associated with large-fibre neuropathy.[1] Testing 10 points per foot is suggested to capture the largest proportion of patients with LOPS and identify the foot at risk for ulceration. The accuracy and durability of 10-gram Semmes-Weinstein monofilaments (SWM) varies commercially. Monofilaments have a, "short service life and should not be used when they have lost 10% or more of their initial bending force".[1] Some monofilaments, excluding single-use products, can evaluate approximately 70–90 patients (10 site testing) and the monofilament requires a 24-hour rest after assessing 10 patients.[1]

Figure 14: Monofilament Testing Sites

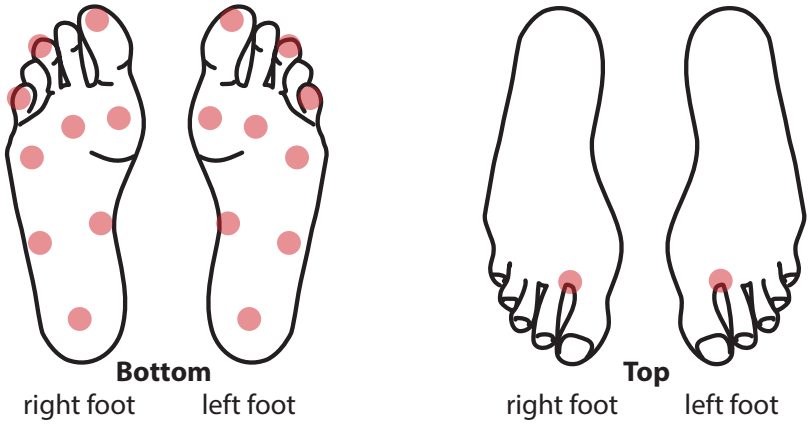
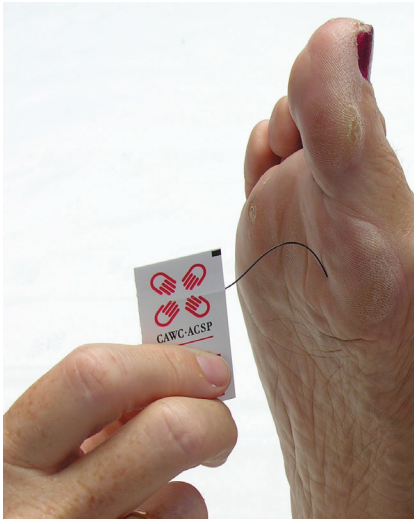


Figure 15: Application of the monofilament



The SWMT uses a 5.07 monofilament that exerts 10 grams of force when bowed into a C-shape against the skin for one second. The IWGDF details steps to correctly use the SWMT.

- First apply the SWMT on the patient's hands, elbow or forehead to demonstrate what the sensation feels like
- Test three different sites on both feet, selecting from those shown in Figure 14
- Ensure the patient cannot see whether or where you apply the filament
- Apply the monofilament perpendicular to the skin surface with sufficient force to cause the filament to bend or buckle (See Figure 15)
- The total duration of the approach -> skin contact -> and removal of the filament should be approximately two seconds
- Do not apply the filament directly on an ulcer, 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 by having them answer Yes/No and where they feel the pressure (e.g., ball of left foot, right heel)
- Repeat this application twice at the same site but alternate this with at least one 'mock' application in which no filament is applied (a total of three questions per site)
- Protective sensation is present at each site if the patient correctly answers on two out of three applications; absent with two out of three incorrect answers
- Encourage the patient during testing by giving positive feedback.

The 128 Hz Tuning Fork Vibration Testing

The IWGDF (2023) details steps to use the 128 HZ tuning fork to do a sensory foot examination. The steps include:

- First, start the tuning fork vibrating by striking it with your hand. Then apply the tuning fork to the patient's wrist, elbow or clavicle to demonstrate what the sensation feels like
- When conducting the actual test, ensure the patient cannot see whether or where you apply the tuning fork
- Apply the tuning fork to a bony part on the dorsal side of the distal phalanx of the first toe (or another toe if the hallux is absent)
- Apply the tuning fork perpendicularly, with constant pressure (See Figure 16)

- 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 out of three applications, and negative if two out of three answers are incorrect
- If the patient is unable to sense the vibrations on the toe, repeat the test more proximally (e.g., malleolus, tibial tuberosity)
- Encourage the patient during testing by giving positive feedback.

Neuropathy is also demonstrated by an inability to sense vibration from a standard tuning fork. A biothesiometer or neurothesiometer can also be used for assessing the perception of vibration.

Figure 16: Correct Application of Tuning Fork

Ipswich Touch Test (IpTT) (Light Touch Test)

The IWGDF states the IpTT has shown, "similar results to testing with the 10-gram monofilament."[2] The IpTT involves the clinician lightly touching or resting the tip on their index finger (See Figure 17) on six or eight sites. Steps to conduct the test include:

- Explain the procedure to the patient/care partner and ensure that everything is understood
- Instruct the patient to close their eyes and to say Yes when they feel the touch
- Test either six or eight sites:
- To test eight sites lightly touch sequentially with the tip of your index finger the tips of the 1st, 3rd, and 5th toes and the hallux of both feet for one to two seconds, **or**
- To test six sites lightly touch sequentially with the tip of your index finger the tips of the 1st, 3rd, and 5th toes and the hallux of both feet for one to two seconds
- When touching, do not push, tap or poke[3]
- LOPS is likely when light touch is not sensed in ≥ two sites whether testingsix or eight sites.

Figure 17: Ipswich Touch Test (IpTT)

References

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Appendix E: Charcot Neuro-osteoarthropathy (CNO or Charcot Foot)

Charcot foot is one of the major complications of diabetes mellitus.[1] There is no singular cause for the development of Charcot foot but well-recognized predisposing factors include diabetes, peripheral neuropathy, increases in local blood flow, excessive osteoclastic activity, unrecognized injury, continued repetitive stress and obesity. In industrialized countries the prevalence of CNO is high: 35% in persons with diabetes.[2-4]

Terminology: It is important to note the terms *neuro-osteoarthropathy* and *neuroarthropathy* are used interchangeably and mean the same thing.

Charcot- associated fractures (usually multiple) may result from normal activities of daily living—in contrast to those caused by overt trauma.

Charcot foot is characterized by sterile inflammation in individuals with neuropathy, leading to bone, joint, and soft tissue damage, potentially resulting in a deformed foot if left untreated (See Table 14). Charcot foot is a progressive condition characterized by four different disease stages:[5]

0 - Inflammation (acute phase): red, increased in temperature, swollen foot (bones, joints and soft tissue), pain minimal due to polyneuropathy
1 - Fragmentation (active phase): increasing bone fragility, collapse of the longitudinal foot arch, osteopenia leading to fractures, and joint destruction (Lisfranc's joint)
2 - Coalescence (less active): less redness of the foot; soft tissue and bone marrow edema may persist
3 - Remodeling, reconstruction or the consolidation phase: occurs when substantial joint and bone destruction followed by proliferations of the bone, the Charcot, rocker-bottom appearance of the foot emerges.

Table 14: Assessment of Charcot Foot[5]

Stage	Description or Characteristics	Image -
0 Inflammation (prodromal, acute phase)	• Dermal flush/redness • Warm, increased skin temperature(compared to other foot), with or without local edema (bones, joints, soft tissue) • Bounding pulses • Skin intact • Evidence of instability of the foot, plain X-ray (foot and ankle) evidence may or may not be seen. MRI may be needed if X-ray negative	
1 Fragmentation, destruction (developmental, active phase)	• Acute developments of CNO • This acute, destructive period is induced by minor trauma resulting in fragmentation of bone and joint dislocation and subluxation • Important stage for clinicians to recognize and where they can make the greatest difference in prevention of significant impairment for the patient	
2 Coalescence (coalescent, subacute, less active phase)	• The patient presents with lessening ofedema and healing of fractures	

cont'd. . . .

3 Remodeling (reconstruction, chronic phase)	• Healing of bone and remodeling on X-ray, plus evidence of deformity	

According to the IWGDF, an increase in skin temperature of 2° Celsius or 4° Fahrenheit (which is actually 2.2° Celsius) of the involved foot compared to the same location on the uninvolved foot has been used as a diagnostic threshold for active CNO. The IWGDF completed a systematic review and could not identify studies demonstrating the diagnostic accuracy of such measurement when using imaging as a comparator for the diagnosis of active CNO. However, there is evidence in regard to elevated temperature as a sensitive indicator of inflammation in diabetic feet and a precursor to ulceration.

In the absence of other signs and symptoms of inflammation (e.g., redness and swelling), an isolated increase in foot temperature may not always be indicative of active CNO and should be interpreted in the context of other clinical findings. Although an essential part of the diagnostic evaluation, isolated elevation of foot skin temperature is not sufficient to diagnose or rule out active CNO. Consequently, unilateral asymmetric temperature elevation is sensitive but not specific in diagnosis of active CNO. There is no evidence to define which method/protocol for infrared skin temperature measurement is most accurate to diagnose active CNO and where, for example on which anatomical locations, these measurements should be performed.[1]

Diagnosis hinges on clinical signs of inflammation and imaging abnormalities, with MRI recommended when plain X-rays are inconclusive.[1]

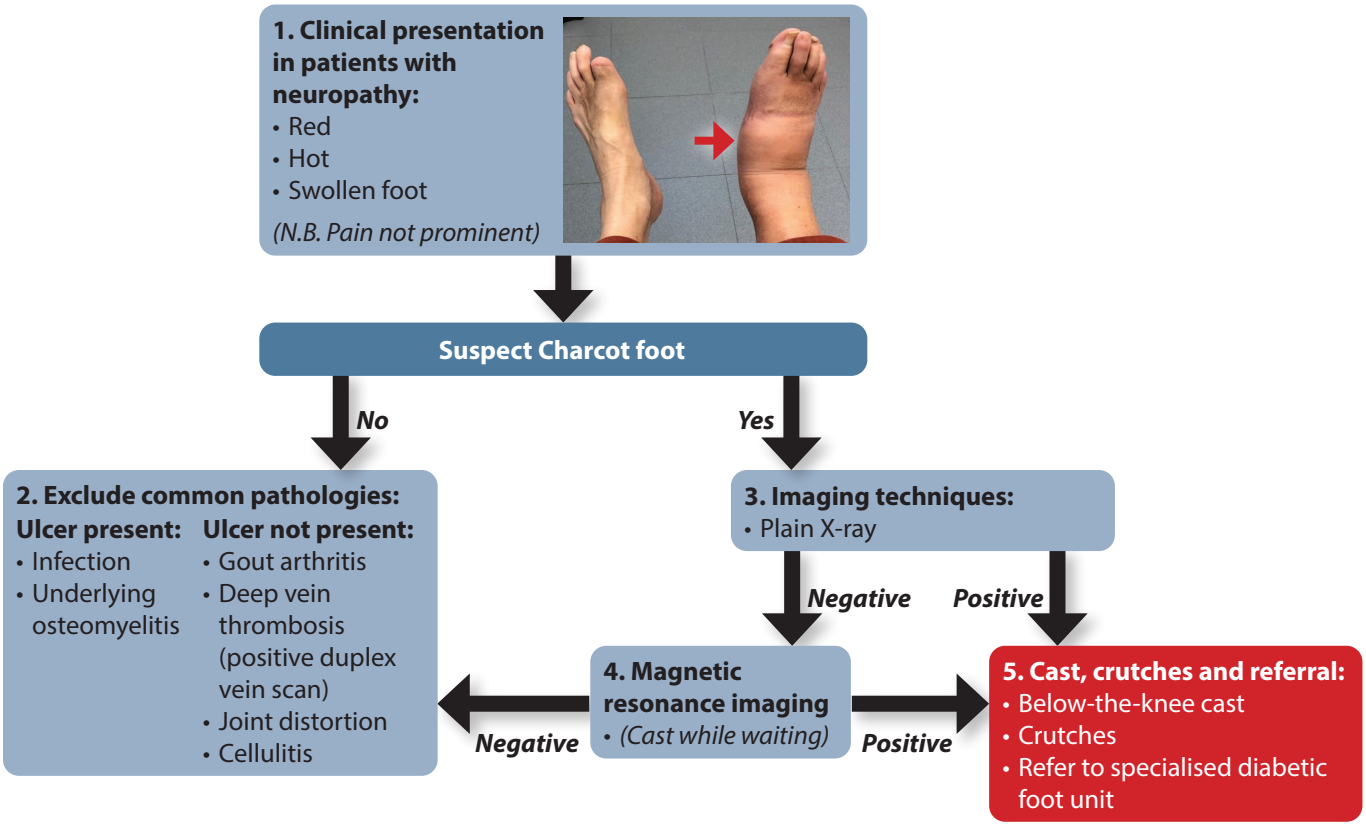
Management of Charcot Neuro-osteoarthropathy

Once a diagnosis of Charcot neuro-osteoarthropathy (CNO) has been made, interventions must be initiated immediately to prevent progression of deformity and subsequent risk for ulcers and amputation.[5] Treatment revolves around immediate plantar pressure management; in the chronic phase, it may require surgical intervention.

Stage of CNO	Charcot Osteo-neuroarthropathy Management[1,5,6]
0 (prodromal)	non-removable knee-high device minimum immobilization: 8–12 weeks
1 (developmental, acute)	non-removable knee-high device immobilization or graduation to removable cast walker
2 (coalescence, subacute)	patellar tendon-bearing brace (PTB) Charcot restraint orthotic walker (CROW walker)
3 (reconstruction, chronic)	custom-made shoes with or without a brace

Treatment emphasizes early offloading and immobilization of the affected extremity using total contact casts or non-removable knee-high walkers, with assistive devices as supplementary options. Offloading should persist until clinical remission with fracture consolidation is achieved, a process that may extend over several months, necessitating close monitoring to prevent complications and adverse effects. See Figure 18: Five steps to manage acute CNO.

Figure 18: Five Steps to Manage Acute Charcot Neuro-osteoarthropathy



Permission granted by D-Foot International.

Medical therapy has limited efficacy in shortening disease duration or preventing deformities, making such interventions not recommended. Supplementation of vitamin D and calcium is advised for individuals with elevated risk of deficiency. Infrared thermometry for skin temperature measurement is a valuable tool for objective disease activity monitoring, although an absolute cut-off value for remission is yet to be defined.

Charcot foot may also be in clinical remission or the, "absence of clinical signs of inflammation, with or without deformity, and radiographic consolidation of fractures, if present, on plain X-ray".[5] Remission is synonymous with the "inactive" stage of CNO.

Charcot foot can be reactivated. This occurs when CNO symptoms recur in the same foot. If active CNO develops in the opposite foot, this is considered a new CNO event. Remission is indicated when there are no clinical signs of inflammation and radiographic consolidation on plain X-rays. Custom-made footwear and orthoses are crucial post-remission to prevent CNO reactivation and optimize plantar pressure distribution. In cases of deformity and joint instability, below-the-knee customized devices may provide additional protection. Gradual foot loading after remission should be implemented, with prompt action in case of recurrence. This comprehensive approach to CNO management aims to improve outcomes and prevent long-term complications in diabetic patients.[5]

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Appendix F: The Self-Assessment Footwear Checklist for Patients[1]

Patients are to ask themselves and check boxes (√) that reflect their present footwear. The tool is to be used to start a conversation about footwear with the patient and/or care partner.	
❑	Are the heels of your shoes less than 2 cm high?
❑	Do your shoes have laces, buckles, elastic or other fasteners to hold them securely onto your feet?
❑	Do you have 1 cm (approximately thumbnail length) of space between your longest toe and the end of your shoes when standing?
❑	Do your shoes have well-padded soles?
❑	Are your shoes made from material that breathes, such as leather?
❑	Do your shoes protect your feet from injury, e.g., cover and protect your entire foot?
❑	Are your shoes safe (e.g., no seams, irregularities) to ensure they cannot cause injury?
❑	Are your shoes the same shape as your feet?
❑	Are the heel counters of your shoes firm?
❑	Are your shoes appropriate for each activity, such as standing for long hours, walking, shopping?
❑	Do they keep your feet dry and free from harm, trauma, injury?
❑	Are your socks made of breathable fabric?
❑	Are your socks smooth, without seams, repairs or rough spots?
Adapted from: Williams A. Footwear assessment and management. Podiatry Management. 2007 Oct; 165-175. Available from: https://podiatrym.com/cme/Oct07%20CME.pdf	

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