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Contact Hours: **9**

Diabetes Care: Prevention and Clinical Care of Diabetic Foot Ulcers

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LEARNING OUTCOME AND OBJECTIVES: Upon completion of this course, you will have gained up-to-date knowledge to care for individuals at risk for developing diabetic foot ulcers and to assess and treat those with diabetic foot ulcers. Specific learning objectives include:

- Identify the prevalence and impacts of diabetic foot ulcers.
- Describe the elements of an interdisciplinary approach to care.
- Discuss the importance of effective patient teaching.
- Summarize the importance of preventive measures for diabetic foot care.
- Describe the role of diabetic peripheral neuropathy and Charcot osteoarthropathy in the development of diabetic foot ulcers.
- List the steps that comprise a foot assessment in patients with diabetes.
- Summarize the management program for patients with diabetic foot ulcers.
- Describe the important components of off-loading in the prevention and treatment of diabetic foot ulcers.
- Discuss amputation as it relates to diabetic foot ulcers.

INTRODUCTION

A diabetic foot ulcer (DFU) is a serious complication of diabetes and one that healthcare providers will encounter across the continuum of care. Diabetic foot ulcers are complex, chronic wounds that are often disabling and greatly impact the morbidity and mortality of patients. Patients who develop a DFU are at higher risk of early death, heart attack, and fatal stroke than people with diabetes who do not develop diabetic foot ulcers (Wounds International, 2013).

Data from large cohort studies conducted across Europe, Asia, Australia, and the United States found that persons with diabetic foot ulcers had higher rates of cardiovascular risk factors such as hypertension and greater susceptibility to cardiovascular disease, in particular heart attack and stroke. Infections related to a DFU and uncontrolled diabetes are also contributing factors to early mortality (Brownrigg et al., 2012).

Various **definitions of a diabetic foot ulcer** include the following types of wounds on the foot of a patient with diabetes:

- An open area or a break in the continuity of the skin barrier that can develop anywhere on the foot and is most frequently found on the bottom of the feet and the toes (APMA, 2016)
- A full-thickness wound anywhere on the foot, usually occurring in high-pressure areas (Scheffler, 2012)
- Areas of callous or blisters on the foot that eventually break down and become open wounds (Wright & Gatenby, 2017)

Diabetic foot ulcers can occur in patients with either type 1 or type 2 diabetes.

History of Diabetes

Diabetes is one of the oldest diseases known to humanity and was first documented by an Egyptian physician around 1552 BCE (McCoy, 2009). The term *diabetes* is Greek and means "to syphon." It was first used around 250 BCE by the Greek physician Aretaeus, who noted how quickly diabetes drained fluid from those affected by it (Dean & McEntyre, 2004).

By the fifth century, the Chinese had noted that people with diabetes were more prone to infection, and in Baghdad in the fifth century, it was observed that people with diabetes developed gangrene in their extremities. During the 18th century, diabetes was discovered to be a systemic disease (Herscovici, 2016).

In the twentieth century several discoveries and advances were made in the diagnosis and treatment of diabetes. Several of the most notable are described in the table below.

HISTORY OF DIABETES CARE	
1916	Dr. Elliot Joslin published the first edition of *The Treatment of Diabetes Mellitus.* Dr. Joslin was known worldwide as a clinician and educator and one of the leading advocates in diabetes care.
1921	Dr. Frederick Banting and Dr. Charles Best (Banting's student at the time) discovered insulin.
1923	Eli Lilly and Company started producing insulin commercially.
1940	The American Diabetes Association was created to tackle the increasing prevalence of diabetes and the complications that developed as a result of the disease.

1949	Dr. Rachmiel Levine discovered that insulin transports glucose into the cells in the body.
1972	The association between elevated blood sugar levels and disease of the blood vessels was reported.
1989	The American Diabetes Association announced its first Standards of Care to better assist physicians in the treatment of diabetes.
1993	The Diabetes Control and Complications Trial demonstrated that keeping blood sugar levels as close as possible to normal slowed the onset of diabetic complications.
Source: ADA, 2014.	

After the discovery of insulin, the treatment of diabetes was revolutionized. With further advances in refining and producing insulin commercially, diabetes evolved from being an acute condition with a limited life expectancy to being a chronic condition. Consequently, patients' longer lifespans resulted in their developing complications related to diabetes, such as diabetic foot ulcers, that required new practices to address them.

Types of Diabetes

Diabetes is not a single disease; rather, it is a condition that includes several metabolic disorders caused by problems with insulin secretion, the manner in which insulin acts in the body, or a combination of both of these (Cypress & Tomky, 2017).

Diabetes has several forms. Three of the most frequently occurring forms are:

- **Type 1 diabetes** (previously referred to as *juvenile onset diabetes*) usually occurs in children and young adults. Between 5% and 10% of people with diabetes have type 1 (Cypress & Tomky, 2017). Type 1 diabetes occurs when the body is unable to produce insulin due to an autoimmune destruction of the insulin-producing cells (beta cells) in the pancreas.

- **Type 2 diabetes** (previously referred to as *adult onset diabetes*) comprises approximately 90% of all people with diabetes (Baker & Fortin, 2016). Type 2 diabetes results from a combination of factors, insulin resistance, and a progressive reduction in insulin secretion. This form of diabetes was typically associated with older adults, but it is now occurring more frequently in young people, adolescents, and children.

- **Gestational diabetes** is found in women during the second and third trimesters of pregnancy, and it can continue beyond delivery. Its symptoms resemble those of type 2 diabetes, and women who experience gestational diabetes are more prone to develop type 2 diabetes later in their lives (ADA, 2014).

Epidemiology of Diabetes and Diabetic Foot Ulcers

Type 2 diabetes is now the most rapidly growing chronic condition **globally,** with over 300 million people worldwide affected. These figures are projected to almost double by the year 2035. Since the possibility of developing diabetes increases with age, the percentage of older adults with diabetes is set to increase along with the increasingly older population.

The 2013 International Diabetes Federation report states that 5.1 million deaths were directly caused by diabetes, and of those, approximately half were in individuals less than 60 years of age (Zoungas at al., 2014).

Almost 80% of people with diabetes live in developing countries, and this number is projected to increase by 170% by 2025. The impact of the disease and the complications arising from it are expected to cause greater damage and have more devastating consequences than in affluent countries (Dube et al., 2015). Statistics show that an amputation of a lower limb happens every 20 seconds worldwide as a result of diabetic complications (Wounds International, 2013).

In the **United States,** 29.1 million individuals (9.3% of the population) have diabetes. Of this number, 21 million people have already been diagnosed, but 8.1 million people are undiagnosed and unaware that they have the condition (CDC, 2014). Annually, 800,000 new cases of diabetes are diagnosed. There is a slight difference in the prevalence between males and females, with 15.5 million males and 13.4 million females having diabetes in this country.

Statistics indicate that approximately 15% of individuals with diabetes that is complicated with neuropathy will develop a diabetic foot ulcer at some point during their lives. Between 14% and 24% of those who develop a diabetic foot ulcer will progress to amputation. According to a report from the Centers for Disease Control and Prevention (CDC, 2014), patients who develop a diabetic foot ulcer have a relapse occurrence of 66% over a period of five years (Varnado, 2016).

U.S. research data indicates that approximately 85% of lower extremity amputations are a consequence of diabetes and begin with a diabetic foot ulcer. After an amputation, the mortality rate rises according to the level of amputation (the higher up on the extremity the amputation occurs, the greater the mortality rate) and varies from 50% to 68% at the five-year mark post amputation. This places the mortality rate associated with amputations in the same category as that from several malignancies (Wounds International, 2013).

DIABETES AMONG YOUTH

The increase in childhood obesity and the occurrence of type 2 diabetes among children continues at a rapid rate. In the years between 2001 and 2009, one study discovered that pediatric type 2 diabetes increased by 30%. In 2012 approximately 208,000 people younger than 20 years were diagnosed with either type 1 or type 2 diabetes (Baker & Fortin, 2016). The highest rate of adolescent type 2 diabetes was among U.S. minority groups. By gender in youth ages 10 to 19 years, the rate of newly diagnosed cases of type 2 diabetes was 6.2% among females and 3.7% among males (CDC, 2017a).

When type 2 diabetes occurs in children and adolescents, it is a much more aggressive disease than in adults. Whereas in adults there is a considerable length of time between diagnosis and the appearance of diabetic complications, in children it has been found that complications can start developing within a few years of disease onset (Curry, 2016). For instance, the UK Prospective Diabetes Study found that the younger the patient's age at the time of diagnosis, the greater the risk for peripheral neuropathy (Zoungas et al., 2014). Thus, clinicians will be treating much younger patients for the complications of diabetes, including diabetic foot ulcers.

DISPARITIES AMONG ADULTS WITH DIABETES

There are also racial, ethnic, economic, and age disparities in the development of type 2 diabetes. In the United States, the highest percentage of newly diagnosed diabetes is found in the Native American and Alaskan Native populations (Baker & Fortin, 2016).

African Americans are approximately twice as likely to be diagnosed with diabetes as non-Hispanic whites. Complications from diabetes are also more common in this population, including lower extremity amputation. In 2012 non-Hispanic black people were 3.5 times more probable to end up in the hospital for a lower extremity amputation in comparison to non-Hispanic white people (Office of Minority Health, 2016).

Socioeconomic status also plays a significant role in the prevalence of type 2 diabetes. Research reveals that living in poverty is a factor that can double or triple the risk of developing diabetes. The risk for uncontrolled diabetes increases when patients have the bare resources to pay for their basic needs of housing, food, and utilities in addition to difficulties in paying for medications and supplies to monitor blood sugar levels. Living in poverty also increases the likelihood of developing complications related to diabetes (Pearson, 2015).

Foot ulcers are the most serious, disabling, and costly complication of diabetes. They most frequently occur in older adults who have had diabetes for several years. Patients aged 65 years and over with diabetes have a two-fold increase in the risk of developing a foot wound and also have the highest number of major lower extremity amputations resulting from diabetes (Matricciani et al., 2015).

ECONOMIC IMPACT

Diabetic foot ulcers are costly to treat. Studies show that patients with diabetic foot ulcers have more emergency room visits, spend more days in the hospital, and require more home healthcare services than patients with diabetes but without diabetic foot ulcers (Rice et al., 2014). The findings from a 2012 U.S. prevalence-based study revealed that the incremental healthcare costs of treating diabetic foot ulcers is $11,700 to $16,883 per patient, which accounts for between $9 and $13 billion annually (Desman et al., 2015).

The National Diabetes Statistic Report determined that the cost of medical care for a diabetic patient is 2.3 times that of a nondiabetic patient. The indirect cost of diabetes and its complications attributed to reduced productivity, disability, and early death have been placed at around $69 billion annually. The potential economic impact in terms of productivity is

significant, since approximately 80% of new diagnoses each year are in individuals under the age of 65 years who are still actively employed (Baker & Fortin, 2016).

INTERDISCIPLINARY APPROACH TO CARE

Diabetic foot care at all stages, both preventive and in treating a diabetic foot ulcer, is based on a multidisciplinary team approach. At different stages of care the members of this team may vary. Various healthcare professionals have many overlapping roles. According to their training, practitioners from each discipline can make important contributions to the care of the patient.

In some cases, patients may be reluctant to agree to a team approach due to the time involved in attending multiple appointments. As far as reasonably possible, patient appointments with multiple providers should be scheduled for the same day at the same location.

Primary Care

Primary care providers, including nurse practitioners, are familiar with the complications that can arise from diabetic foot ulcers and the evidenced-based treatments that will prevent their development. Many patients with diabetes will be treated by a primary care provider, while others may be referred to an endocrinologist.

The primary care provider plays a key role in ensuring that all members of the patient's healthcare team are aware of the medical decision-making and the patient's current status. For example, if the primary care provider believes that the time is drawing close to switch the patient from oral medication to insulin to maintain adequate control of their diabetes, then this information will be shared with the other team members, so that each clinician can help prepare the patient for the transition.

Nursing

Nurses play a pivotal role in caring for patients with diabetes. In virtually every practice setting, nurses encounter patients who have diabetes and must be equipped with the knowledge and skills to care for these patients. As well as providing hands-on care, nurses function as educators, patient advocates, and coordinators of patient care. They also provide the patient with emotional support and recognize that the complexity of diabetic treatment, self-management, and the multiple goals and lifestyle changes that patients have to work toward demand a tremendous amount of not only physical but also psychological adjustment and require consistent, empathetic support.

The nursing role in diabetic foot care includes:

- Patient assessment and screening
- Education
- Advocacy

- Coordination of patient care
- Community outreach

Physical Therapy

Physical therapy professionals assist patients with diabetes through all stages of care, starting with preventive foot care. In diabetic foot care, physical therapists play a major role in the following areas:

- Joint mobility
- Strengthening
- Assessment and management of skin integrity
- Management of swelling (edema)

A physical therapist can create an individualized exercise program with the patient, including aerobic and resistance exercises to help the patient meet weight loss and activity goals. Other interventions used by physical therapists to treat diabetic neuropathy and/or ulcers may include the following:

- Thermotherapy (infrared, global heat, ultrasound)
- Electrotherapy (e-stim, shockwave therapy, laser treatment, magnetic field treatment, galvanic current treatment)
- Therapeutic exercise (joint range of motion, stretching, Buerger-Allen exercise, proprioception/balance exercises)
- Shoe/footwear modification
- Prophylactic patient education (skin inspection, foot/toenail care, etc.)
  (Turan et al., 2015)

Musculoskeletal complications, which affect the foot in many patients with longstanding diabetes, put patients at elevated risk for developing skin ulcers. Alterations in the structure of the foot, including loss of flexibility and limited joint mobility, impede the foot's ability to absorb and redistribute forces related to impact while walking. Foot deformities play a major role in increasing plantar pedal pressure, particularly at the metatarsophalangeal and subtalar joints (Zakaria et al., 2008).

Physical therapists can identify early structural changes in the foot, evaluate a patient's gait, and assess for signs of ulcerations. Physical therapy works closely with patients who have diabetes to minimize balance dysfunction that can occur with peripheral neuropathy. They can also advise patients on footwear, inserts to existing shoes, and techniques for weight distribution along the surface of the foot (Ohtake, 2010; Bryant & Nix, 2016).

Occupational Therapy

Occupational therapists are actively involved in diabetic foot care in a variety of clinical settings: acute care, long-term care, clinics, and community care. Apart from the functions that occupational therapists share with other members of the diabetic healthcare team, they address important areas of everyday life for patients with diabetes, including physical, cognitive, psychosocial, and sensory aspects.

Occupational therapists are instrumental in assisting patients with diabetes to integrate self-care activities into their existing routines. Occupational therapists also help patients overcome barriers to community participation, which is especially important to patients with limited financial resources. Studies have shown that interaction with community amenities has a positive bearing on self-management outcomes for diabetic patients. Community and senior centers can provide patients with healthcare information, and activities that enhance physical, emotional, and social well-being of the patient (Marmolejo, 2017).

Occupational therapy interventions in diabetic foot care include:

- Assessing the patient's skills and competencies
- Assessing the patient's environment and need for adaptation
- Educating the patient on energy conservation techniques
- Teaching patients how to use adaptive equipment
- Assisting patients with work and community participation
- Teaching stress management techniques
- Advising patients on meal planning and preparation
  (Dieterle, 2012; Roberts & Robinson, 2014)

Case Management

A case manager or social worker—although not directly involved in hands-on care of the patient—is an essential member of the diabetic foot care team. Case management in diabetic foot care provides:

- Patient assessment
- Input into the development of the patient plan of care
- Facilitation of services
- Patient advocacy

The case manager has clinical knowledge regarding the management of the diabetic foot and the treatment and management of diabetic foot ulcers should they develop.

The case manager is involved in patient assessment, developing the plan of care along with other team members, facilitation, and patient advocacy. The case manager or social worker helps the patient in navigating the healthcare system and identifying what resources are available, for example, insurance or Medicare benefits to purchase diabetic shoes or adaptive equipment.

For patients concerned about how their diagnosis and treatment will affect their employment, the case manager or social worker educates the patient on their rights under the Family Medical Leave Act (FMLA) and how to apply for FMLA leave through the human resources department at their place of employment. The case manager can also be instrumental in advocating for workplace modifications with an employer.

Diabetes Educator

Clinicians who specialize in diabetes care and education can become Certified Diabetic Educators (CDE) through the National Certification Board for Diabetic Educators, founded in 1986. This qualification is available to nurses, occupational therapists, physical therapists, and other professionals who meet the examination requirements. Clinicians are expected to be already working in the area of diabetic education and providing diabetic self-management education to patients. The exam to become a CDE is not an entry-level exam, and clinicians taking this exam must be knowledgeable and experienced in diabetic care.

The CDE functions as an educator and advocate for patients of all ages with diabetes and across the continuum of care. The CDE has expertise in teaching diabetes self-management skills to patients with diabetes and is a valuable resource for other clinicians who work with patients who have diabetes (NCBDE, 2018).

(See also "Resources" at the end of this course.)

Podiatry Care

All patients with diabetes should have a podiatry consult as part of preventive care. A podiatrist will diagnose and treat conditions of the foot, ankle, and related structures of the leg, including diabetic foot care. The podiatrist works in close association with other members of the patient's healthcare team to ensure that recommendations for care are integrated into the treatment plan for the patient.

A podiatrist provides the patient with diabetes with:

- Specialized foot assessment
- Identification of bone and joint deformities that can lead to areas of high pressure on the feet
- Recommendations for care, including prescriptions for inserts or diabetic shoes
- Education regarding foot care

- Early detection of complications
  (Scheffler, 2012)

Orthotic Care

An orthotist can play a part in the care of the patient with diabetes by evaluating the patient for an orthosis, which can serve the following purposes:

- Assist with movement of the extremity
- Restrict movement in a particular direction as needed, to help reduce inflammation and improve stability and function
- Reduce weight-bearing and relieve areas of excessive pressure to the feet
- Reduce pain in the affected extremity

Orthotic devices used in diabetic foot care include ankle braces, shoe inserts, and footpads. Removable insoles in shoes provide pressure and shock absorption. When a patient is prescribed a shoe insert such as removable insoles, they are advised to wear their regular shoes to the fitting so that the foot care specialist can fit the appropriate insert for that shoe.

For patients with diabetes who have lost even partial sensation in their feet, it is recommended that they are fitted for individually modified shoes by a pedorthist or other trained foot care specialist (AOFAS, 2017). A pedorthist has special training in the properties of footwear and the interactions between the patient's feet and the shoes that they wear. Customized shoes for patients with diabetes are provided by the pedorthist. The goal of care is to provide nonsurgical intervention either to relieve a foot problem or to prevent it from becoming worse (PFA, 2018).

(See also "Resources" at the end of this course.)

Additional Team Members

Dietitians commonly see the patient once a diagnosis of diabetes is established or when weight management is identified as part of the patient plan of care. Since many patients with diabetes also have concurrent problems with arterial circulation to their feet, a consult to a vascular surgeon will frequently be ordered. A neurologist maybe consulted to perform nerve testing and assess the severity of peripheral neuropathy present.

PATIENT TEACHING

Educating patients with diabetes to manage their condition and to adopt lifestyle changes that will prevent or delay the occurrence of diabetic complications is a widely recommended practice. While certain clinicians hold specialized qualifications in diabetes education, every healthcare provider must be knowledgeable in basic diabetes education, especially when it comes to care of the diabetic foot. For instance, one retrospective study found that diabetes education provided by

staff nurses decreased the seven-day hospital readmission rate for patients with diabetes from 6.2% to 2.5% (Corl et al., 2015).

The goal of diabetes self-management education is to provide the patient with the necessary knowledge and skills to incorporate practices into their daily lives that will allow them to remain healthy and prevent complications. If the patient's foot care is being done by someone else, such as a family member, that individual, with the patient's permission, is also included in the teaching sessions.

Teaching Newly Diagnosed Diabetes Patients

When a patient is first diagnosed with diabetes, teaching focuses on what is immediately necessary to keep the patient safe, such as learning how to check blood sugars, administer insulin, and make dietary changes. To clinicians, these actions may all seem straightforward and easy to accomplish. However, to a patient who has never held a needle or syringe or who is accustomed to eating only "junk food," dealing with even the essentials of diabetes care can be unnerving. Clinicians must therefore see education as an ongoing process and not merely a few sessions with a diabetes educator or a dietitian.

A frequent complaint from many patients with diabetes, particularly after they have been newly diagnosed with diabetes, is that "there is too much to remember." Clinicians have to be mindful of this and summarize teaching into two or three major points, such as:

1. A healthier diet
2. More physical activity
3. Smoking cessation

Patients are reminded that even small advancements in these three areas will improve their general health and decrease the likelihood of developing foot problems.

Individualizing the Teaching

Although the steps in preventive diabetic foot care are basically the same for all patients, teaching is individualized to meet the particular needs of each patient. Various factors are taken into consideration when devising a teaching program, such as:

- **Age of the patient.** Impairment in cognitive ability with aging occurs in more than 5 million people in this country who are over the age of 70 years (Parnell, 2015).

- **Language.** Does the patient speak English, is it their first language, and is it their preferred language for health education? Will the clinician need an interpreter present for teaching?

- **Literacy.** One in five persons in the United States read at or below the fifth-grade reading level (LCN, 2018).

- **Health Literacy.** Low health literacy abilities can affect individuals of all grades of literacy (Parnell, 2015).

Clinicians must also ensure that the teaching materials are appropriate for the patient. Handing a male in his late 20s a pamphlet on daily foot inspections with pictures of an elderly male will not convey the correct message; the young patient's unspoken response may be, "I can wait to check my feet until I'm old." It may also be ineffective to give a middle-aged African American woman living in a rural area educational materials that portray a white female living in a middle-class suburban neighborhood. Patients must be able to identify with the examples and the instructions in the educational materials in order for meaningful learning to take place.

Clinicians must be aware of the **cultural influences and health beliefs** of the patient. It is important to explore with the patient what they already know about diabetes, diabetic foot care, and how diabetes is perceived in their culture. For example, research data indicates that close to 9% of Latinos use complementary and alternative medicines—such as canela (cassia cinnamon) to help regulate blood sugar levels—although there may be scant scientific evidence to show that these treatments work (Martinez-Tyson et al., 2012).

The role of **socioeconomic factors** is also part of formulating education for patients. The clinician must consider whether any of the recommended interventions will be financially burdensome on the patient. It can be easy to label a patient as "noncompliant" when the real reason they are not participating in their care is their inability to purchase the long-handle mirror, insoles, or shoes recommended by the clinician. What alternatives and suggestions can the clinician offer to help offset these costs?

Listening and Speaking Effectively

Effective listening and speaking are vital to establishing the partnership needed between the clinician, patient, and other caregivers to achieve the common goal of preventing foot ulceration.

In her highly popular book *Kitchen Table Wisdom* (1996, p.143), Dr. Rachel Naomi Remen writes, "I suspect that the most basic and powerful way to connect to another person is to listen, just listen. . . . When people are talking, there is no need to do anything but receive them." When clinicians practice **empathetic listening** with a patient in an environment in which the patient feels "safe" to talk, they usually hear the real reasons why self-care is not being done, either directly or indirectly (e.g., "I can't stand my wife fussing over me to check my feet; it makes me feel like an invalid").

The **clinician's language** when teaching is very important. Staying away from medical terminology and jargon as much as possible is vital for successful communication. Sometimes patients can be too stressed and too weary to request a clarification of information they may not understand. For this reason, it is helpful if a family member or other caregiver is part of the education process, with the patient's permission.

Clinicians can probably speak volumes about the terms *risk* and *benefit,* but to many patients these terms are vague and not easily conceptualized. When teaching preventive care to a patient with diabetes, benefits and risks must be clearly explained in concrete terms.

Consistency in terminology is imperative. If during the first encounter with the patient, the clinician talks about a diabetic "foot ulcer" but at a subsequent visit refers to a diabetic "wound," this may convey different meanings to the patient. Many people see a wound as something that is cleaned up and heals quickly, whereas an ulcer will be there for a long time.

PREVENTIVE FOOT CARE FOR PATIENTS WITH DIABETES

More and more emphasis is now being put on preventive measures rather than exclusively on treatment of diabetes and its complications. Preventing diabetic foot ulcers is of prime importance and must be the focus of every clinician at every encounter with the patient. Prevention of diabetic foot ulcers focuses on two specific factors: foot care and control of the underlying diabetes.

Health and Family History

The first step in preventive care is getting to know as much as possible about the patient's health history, including family history. Taking time to get to know the patient is critical to successful treatment outcomes. Not only does the clinician glean useful information, most importantly they lay the basis for good rapport with the patient. Questions that the clinician asks are:

- How long since the patient was first diagnosed with diabetes?
- What was the patient's initial reaction to the diagnosis? Many patients will state that they got "very serious" about their healthcare immediately, while others will describe minimizing the diagnosis, stating that they were "feeling fine" at the time and did not see any need to make changes in their routine or lifestyle.
- What comorbidities does the patient have, such as heart disease, respiratory conditions, or musculoskeletal impairments (Baker & Fortin, 2016).
- What is the patient's level of cognitive function and the presence of depression? Research shows that 12% to 27% of individuals with diabetes are affected by depression. It has also been found that persons with a mental health condition have a higher risk of developing diabetes. Studies also indicate that about half of those diagnosed with diabetes exhibit decreased psychological well-being at the time of diagnosis. A study conducted internationally demonstrated that diabetes-related distress occurred in 13% to over 44% of patients with diabetes (Baker & Fortin, 2016). All of these findings impact the patient's ability to perform self-care and must be taken into consideration by the clinician.

- Does the patient have a family history of diabetes? If so, how did the family member(s) deal with diabetes and what complications did they have? These are details that can greatly influence how a patient views their own condition. If, for example, a patient's mother had diabetes and died from heart disease in her mid-fifties, the patient may see diabetes as a fatal condition that will greatly shorten their own life.

Limb Assessment

Being aware of the condition of the patient's lower extremities helps the clinician to identify the patient's level of risk for developing diabetic foot ulcers, and this will help guide the interventions needed at this stage to prevent ulcers occurring.

The patient is asked or assisted to remove their shoes and socks, and a careful assessment is made of each leg and foot. Each limb should be compared with the other and any differences between the two of them noted. While assessing the general appearance of the limb, the clinician is observing for the following:

- **Color.** Paleness may indicate poor circulation, while redness could be a sign of inflammation or the early stages of Charcot osteoarthropathy (degeneration and destruction of weight-bearing joints) (Cypress & Tomky, 2017).
- **Dryness.** Skin surfaces that are dry, flaking, or cracked may be an indication of impaired circulation.
- **Hair distribution** on each leg. A lack of hair growth can also be an indication of poor circulation, in particular arterial circulation.
- **Edema.** This is determined by pressing firmly but gently over the areas of swelling using the index finger. Edema is also a finding in problematic circulation.
- **Fissures.** These are dry, deep cracks in the skin, particularly on the heels, and can be a sign of neuropathy.
- **Callous formation.** This may indicate of an area of excessively high pressure.
- **Fungal infection,** especially between the toes, can be attributed to poor foot hygiene.
- **Bunions** at the base of the great toes can indicate footwear that is too tight.
- **Corns** may indicate rubbing or pressure from ill-fitting shoes.
- **Bony deformities** can be a finding in ill-fitting footwear.

During the hands-on assessment, it is also important for the clinician to determine whether the patient can reach and see their own feet. In the event that the patient has difficulty doing so—for example, a patient's arthritic joints makes them unable to see the bottoms of the feet—then the clinician identifies assistive devices that will allow the patient to perform proper foot checks on themself.

Over the course of life, the anatomy and function of the feet change. Normal age-related changes include the fat pads on the bottom of the feet gradually becoming thinner, the arch of the foot frequently becoming flatter, and the foot becoming longer and wider. When examining the feet of patients with diabetes, the clinician distinguishes such age-related changes from changes related to diabetes.

Foot Care

Daily foot care practices for the patient with diabetes are a vital part in preventing diabetic foot ulcers from developing and are an important self-management goal. For everyone involved—the patient, families, and clinicians—it is important to keep in mind that even small changes can make a big difference.

When patients understand why foot care is important, they are more likely to do it. A generalized statement that "diabetes can damage your feet" is not sufficient. The clinician does not need to go into lengthy explanations regarding the pathophysiology of diabetes. Instead, they explain that diabetes can cause two important changes that affect the feet:

1. There may be a **gradual loss of feeling to the feet**, which the patient will not always be aware of. This can be explained to the patient in practical terms: "When you lose feeling in your feet, you may not feel a small stone or even a nail inside your shoes. You may not know that you have developed a blister or a cut on the sole of your foot. A diabetic foot ulcer can begin with something as seemingly insignificant as a small cut (nick) that happens when trimming toenails."

2. Diabetes can cause **decreased blood flow to the feet**. Again, the practical implications of this can be explained to the patient by stating, "Poor blood flow to your feet makes it much harder for any injury to your foot to heal, even a small wound. This can cause a small cut to turn into an ulcer."

ELEMENTS OF GOOD FOOT CARE

- **Preventing skin breakdown.** The skin covering the feet provides a physiologic barrier to bacterial and fungal invasion of the tissues and bones of the feet. Skin integrity is therefore of major importance to all patients but especially to patients with diabetes, who have compromised healing (Burdette-Taylor, 2016).

- **Maintaining the normal structure and function of the feet.** This is crucial to the patient's mobility.

The following elements of good foot care comprise the instructions that the clinician teaches and discusses with every patient who has diabetes and reinforces at every follow-up visit:

- **Conduct daily foot checks.** Ask the patient to remove their shoes and socks and show them how to do a foot check. Every part of the foot—the tips of the toes, between the toes, the back of the heels, and the ankle areas—are to be inspected. Instruct the patient to

look for red spots, blisters, cuts, swelling, and infected toenails. Many patients are unable to see the bottoms of their feet, which make foot checks difficult and can result in areas of redness being missed. In this instance, patients should be instructed in the use of a long-handled mirror to visualize all areas of their feet.

- **Wash the feet every day.** Instruct the patient to wash their feet with mild soap and water. Remind patients who have a lack of sensation in their feet to check the temperature of the water with a hand before immersing their feet in order to avoid the possibility of burns. After washing, dry the feet carefully, rubbing gently to avoid chafing. Particular attention must be paid to drying between the toes, since moisture left in the web-spaces can contribute to a yeast infection. Washing the feet does not mean soaking them in water; foot soaks have been shown to break down the natural skin barrier and predispose the patient to ulcer formation (Byrant & Nix, 2016).

- **Perform skincare.** Advise the patient to massage a thin coat of skin lotion onto the tops and bottoms of their feet after drying. Explain that lotion should not be put between the toes. A light dusting of talcum powder or cornstarch can be used to keep the skin between the toes dry. However, the patient must be cautioned against putting excessive powder between the toes, since this will lead to clumping and possible excoriation.

- **Never walk barefoot.** Most people believe that it is safe to walk in their bare feet in their own homes, and everyone has done this at some time. For a patient newly diagnosed with diabetes, it may seem nonsensical to suddenly have to wear socks and shoes (or sturdy slippers) at all times, even in their own living room. The clinician explains that inadvertently stepping on everything from a sewing needle to a sesame seed has been found to cause a diabetic foot ulcer.

- **Check shoes before putting them on.** Prior to putting on their shoes, instruct the patient to check for objects inside the shoe and ensure that the lining of the shoe is smooth and wrinkle-free. Patients with small children or grandchildren, for example, have found Lego pieces and small toys in their shoes.

- **Protect feet from extremes of temperature.** Properly fitting shoes worn at the beach provide protection against hot sand. Also caution the patient against using hot water bottles, electric blankets, or heating pads. Advise the patient to wear socks at night if they have cold feet. If a patient insists on wearing sandals during the summer, recommend putting sunscreen on the top of the feet to protect against sunburn.

- **Improve circulation to the feet.** Good circulation is fundamental to maintaining healthy feet. Teach the patient to put their feet up whenever they are sitting and not to sit for long periods of time with their feet in a dependent (dangling) position. Patients should not sit with their legs crossed for an extended time, and they should be instructed in simple exercises to do at home, such as wiggling their toes and flexing their ankles for five minutes a few times each day (NIDDK, 2017). Caution the patient against wearing tight socks or elastic/rubber bands or garters around their legs to hold up stockings, as all of these can interfere with circulation.

HOW OFTEN IS A FOOT CHECK NEEDED?

A commonly asked question among patients with diabetes is: "When should I check my feet, and how long is it going to take?"

The best way to respond to this question is to have the patient repeat the foot check process without instructions or guidance from the clinician. This is a better indicator of the time required than simply telling the patient, "It will only take a few minutes."

As to how frequently foot checks should be done, the clinician reinforces with the patient the need to make this part of a daily routine. A foot check can be compared to brushing one's teeth; it is a good practice to do a foot check in the morning before putting on any footwear and again at night when the patient takes their shoes and socks off.

INDICATIONS FOR CONTACTING A HEALTHCARE PROVIDER

Patients are given clear instructions on when they should contact their healthcare provider as a result of their regular foot care. For example, "Contact your doctor's office as soon as possible if you notice any of the following changes:"

- You start to feel pain or cramping in the legs or buttocks while you are walking or doing other physical activity
- Your feet are burning, hurting, or tingling
- You cannot feel when someone touches your foot
- You cannot tell very well whether something is hot or cold when it touches your foot
- You notice a change to the shape of your foot
- The color of your feet start to change and they feel warmer than normal
- You begin to lose any former hair growth on your legs, feet, and toes
- The skin on your feet is dry and cracking
- The areas between your toes become red, damp, and itchy
- Toenails that were healthy and normal turn yellow and thick
- You find blisters, cuts, callouses, infected corns, or ingrown toenails on your feet (CDC, 2017b)

BARRIERS TO PROPER FOOT CARE

Despite the positive benefits of foot care practices, studies demonstrate that only a small percentage of those diagnosed with diabetes engage in daily foot exams. The data from one large study showed that only 20% of patients with diabetes did daily foot inspections. In another study,

60% of participants stated that they did not perform routine foot care because they did not regard it to be an important part of their self-care (Matricciani, 2015).

Clinicians must remain aware of how difficult it can be for patients to make and maintain substantial changes to their lives, especially after receiving a diagnosis of diabetes. The emotional response and shock of being diagnosed with diabetes can be a major barrier for learning and self-management. This new diagnosis is something that can impact every facet of a patient's life. Under such overwhelming circumstances, looking at one's feet every day can seem trivial and unimportant.

It is the responsibility of the clinician to create a shame-free environment and to show respect and caring, even when it is difficult for the clinician to understand why a patient may not perform the care that they know to be important to their own well-being.

Appropriate Footwear

Proper footwear should be incorporated into diabetes care from the onset of diagnosis since it is a crucial part of preventing diabetic foot ulcers. Poorly fitting shoes are frequently cited as one of the foremost causes leading to the development of diabetic foot ulcers and may contribute to around half of all diabetes-associated amputations (Connolly & Wrobel, 2014).

The clinician assesses the patient's footwear at the first visit and then at regular intervals, since changes may occur in the size or shape of the patient's foot due to edema or Charcot foot (discussed later in this course), necessitating additional adjustments and modifications to shoes (Connolly & Wrobel, 2014).

Most everyone wants to wear nice shoes or sandals, and one of the first complaints from patients with diabetes is that specialized diabetic footwear is ungainly and ugly. At first this may seem like a trivial complaint when compared to the seriousness of developing a diabetic foot ulcer and the real potential for amputation. However, the clinician realizes that the patient is probably not thinking along those lines. Instead, they may see the loss of "normal" footwear as another unwanted indicator that a chronic disease is putting limitations on their lives. Coming from this standpoint, the clinician works with the patient in finding footwear that protects their feet but is still aesthetically pleasing to the patient. This ensures better treatment adherence on the part of the patient and better outcomes.

ELEMENTS OF PROPER SHOE FIT

The clinician educates the patient on the importance of choosing the appropriate shoe.

The **shape and size** of the shoe must be assessed, and the patient advised to, as far as possible, match the shape of the shoe to the shape of the foot, both in width and length. A properly fitting shoe will have sufficient room in the toe area, over the instep, and across the ball of the foot. The shoe should fit snugly around the heel area.

A shoe with **laces** is a better choice for a patient with diabetes than a slip-on shoe because it provides better support and allows for adjustments needed for swelling, deformities, and different sock thicknesses (AOFAS, 2017).

For patients with diabetes who have intact sensation in their feet and no evidence of foot deformities, an ideal choice is a correctly fitting pair of shoes produced from **soft materials** (such as soft leather) with the capacity to stretch.

Shock absorption is an important consideration for the patient with diabetes, and a cushioned sole rather than fine leather soles will provide for better shock absorption.

It is essential that shoes provide good **support and protection** for the feet, and the back of the shoes need to be strong enough that they will not collapse downwards or to either side, leaving the heels exposed to injury.

Ideally, patients with diabetes should have **more than one pair** of comfortably fitting shoes, and it is a good practice to alternate shoes on an every-other-day basis. This will help to extend the life of both pairs.

"WHAT ABOUT THE SHOES I AM WEARING NOW?"

This is a question that a patient will commonly ask. To answer, the clinician assesses the patient's shoes, observing their overall condition, size, fit, and design in relation to the shape of the patient's foot. The clinician notes the wear stress along the soles and heels and looks for thinning areas along the bottom of the shoes and the surface of the shoe lining. Are there bulges on the outside of the shoes? Excessive wearing down of the heels? Are the heels too high and too narrow?

While it may be apparent to the clinician that a patient's shoes are not a good fit and are placing the patient at risk for developing a diabetic foot ulcer, the patient may be reluctant to accept the clinician's findings. For instance, perhaps the shoes are relatively new and were expensive to purchase, the shoes are a favorite pair, or "they've never caused any problems in the past."

Arguing with the patient is counterproductive. A better approach is to provide the patient with a tracing pattern of their feet by drawing a simple outline. The patient stands with both feet on pieces of nonslip paper, with their weight evenly distributed over both feet, while the clinician traces around both feet. The clinician or the patient then places the shoes over the tracing and objectively assesses how well they match up. If the shoes are shorter, longer, wider, or narrower than the tracing, they are not appropriate (Varnado, 2016).

Another concern is uneven weight distribution and the creation of high–pressure point areas. A quick and inexpensive way to check for this is by using a Harris mat, which is a foot imprint system. One side of the mat is permeated with ink and the other is clear. The patient is requested to remove their shoes but to leave their socks or stockings in place. The patient then takes a normal step onto the uninked side of the mat, leaving an impression of the foot on the mat that highlights areas of uneven weight distribution and high pressure (Driver et al., 2016).

This then allows the clinician to recommend appropriate orthotic devices to relieve pressure (or to refer the patient to an orthotist or podiatrist for further evaluation).

BUYING NEW SHOES

Patients with diabetes need to be aware of the condition of their shoes and when shoes need replacing. Signs that shoes need to replaced include:

- Heel shape that no longer provides support and collapses when the patient puts the shoes on
- Holes in the lining of the shoe
- Worn, uneven heels, which can produce an unsteady gait and/or increase the risk for excessive pressure points
- Thin, worn sole

Cost and fondness for a "worn-in" pair of shoes can make patients reluctant to purchase a new pair. The clinician must stay vigilant and point out to the patient when a new purchase is required to maintain healthy feet.

The clinician offers patients these instructions regarding purchasing shoes:

- Have your feet and proper size measured each time because feet change over time, especially with aging.
- Shop in the afternoon rather than the morning because feet swell during the day, especially if you have concomitant heart and kidney disease.
- Wear the socks, or type of socks, that you normally wear when you go to purchase new shoes. This will help to ensure that the shoes will fit properly for everyday wear.
- Measure the distance between your longest toe and the tip of the shoe. This is best done with the shoes on, pressing down on the empty space at the front of the shoe. This empty space should be one half of your thumb's width to allow for an adequate fit.
- Break in new shoes gradually before wearing them for extended lengths of time. Wear new shoes for one to two hours, remove them, and check the feet for cuts, blisters, spots of redness, or bruising. If none of these are present, wear the shoes for three to four hours the following day and each day gradually increase the wear time. If shoes are causing problems, do not "tough it out"; return the shoes to the store if the store's return policy allows and start again with a different type of shoe.
  (Joslin Diabetes Center, 2017)

Sometimes it is hard for a patient to find the type of shoe they need "off the rack." Clinicians can also remain aware of local shoe stores that carry footwear supplies especially for patients with diabetes and store staff who are able to assist a patient in choosing appropriate footwear.

COMMON FEATURES OF INAPPROPRIATE FOOTWEAR

- **Seams.** Seams can cause repeated shear and friction as well as pressure to the areas of the foot that they come in contact with, which are mainly the dorsal forefoot and the toes. Depending on the type of shoe, more than one seam may be present. Patients with diabetes are advised to shop for shoes that are seamless.

- **Narrow toe box.** A lack of space in the toe box can result in diminished circulation and increased pressure to the toes. This lack of space can result in callus and blister formation. It is important for the clinician to remind the patient with diabetic peripheral neuropathy that just because a shoe does not feel tight does not mean that it is not. The patient needs to carefully examine the shoe and use good visual judgment in deciding whether or not the shoe is a good fit.

- **High heels.** High heels can cause the development of pressure points on the balls and heels of the feet that can result in calluses and subsequent development of diabetic foot ulcers. It is recommended to wear shoes with broad, square heels that are less than 1 to 2 inches in height (Reynolds, 2017).

- **Insufficient length.** The length of a shoe is just as important a consideration as the width. The length of the shoe should allow a 3/8- to 1/2-inch space between the patient's longest toe and the end of the shoe (AOFAS, 2017).

- **Thong-style sandals and flip-flops.** This type of footwear has become very popular with all age groups. However, it poses risks for patients with diabetes due to increased exposure of the foot and toes to possible injury.

SOCK SELECTION

Socks must also be considered when reviewing footwear with a patient who has diabetes. It is possible to purchase socks that are specially made for patients with diabetes in stores and from websites that specialize in diabetic supplies. For instance, compression socks, which typically indicate the degree of compression on the packaging, may be needed.

However, if the patient prefers to buy socks in "regular" stores, they are advised to avoid socks with seams that could possibly cause pressure and to look for socks that wick moisture away from the skin. Controlling moisture is very important for patients with diabetes to reduce the risk of weakening the natural skin barrier and the possibility of fungal infection.

Whether the patient is buying special diabetic socks or regular socks, the features to look for include:

- Nonelastic cuffs
- No prominent seams (turn socks inside out and run the fingers along the seams to determine how soft or coarse they are)
- Socks that keep the feet warm, especially for winter use
- Socks that allow the feet to "breathe" and sweat and that wick moisture away from the skin surfaces, particularly during the summer months
- Size (neither too tight nor sagging)
- Built-in cushioning along the bottoms for extra relief from pressure
- Light color, to alert the patient to drainage

Cotton socks absorb moisture, but they do not wick moisture away from the skin. Wool socks are usually lightweight and give good insulation; they also allow the skin to breath and absorb moisture away from the skin. Socks that are made from a mix of high-quality fibers usually provide the best wear time, comfort, and protection.

Patients should be reminded to always wear socks when they have shoes on and to change their socks every day.

Patients with diabetes often experience swelling in their lower extremities, but since most of these patients also have peripheral arterial disease, high levels of compression therapy cannot be used. However, studies have shown that mild levels of compression (18 to 25 mmHg) help to relieve swelling while not compromising arterial circulation (Wu et al., 2012). Thus, in patients with lower extremity swelling, the clinician discusses the value of wearing socks with mild compression.

Foot Biomechanics

Biomechanics refers to how the body moves and what impacts that movement. Two primary goals of biomechanics interventions are injury prevention and rehabilitation. Biomechanical problems can lead to an array of negative consequences on ambulation and pursuit of recreational activities as well as result in an increase in musculoskeletal comorbidities. Thus, knowledge of the biomechanics of the foot is an essential part of the assessment of the diabetic foot and an important component in preventing diabetic foot ulcers.

The **gait cycle** refers to one full step, beginning with either the right or left foot, from heel contact of the first foot to heel contact of the second foot. The gait cycle is further divided into the stance phase (60%), which occurs when the foot is in contact with the ground, and the swing phase (40%), which occurs when the foot is free floating.

Proprioception refers to an awareness of the body's position in context with the surrounding environment (Bryant & Nix, 2016). Through proprioception, one knows their location in space and how to navigate through it. This functioning is accommodated by specialized nerve endings known as *proprioceptors,* which are found in the soft tissue of the musculoskeletal system. Next to the spinal cord, the foot is the area of the body with the most proprioceptive sensory receptors.

Damage to the feet will result when there is reduced proprioception. A lack of, or inadequate, information provided by proprioceptors has a negative impact on movement, postural coordination, and pressure (weight) distribution. In a diabetic foot with advanced neuropathy with loss of protective sensation (LOPS), diminished proprioception response is evident by unsteady gait, loss of balance, and unequal stress and weight-bearing on the feet.

When excessive weight is applied to a section of the foot, this overloading causes an overpowering, intense force that leaves no time for the skin to shield itself from injury. At this stage, blistering occurs. When there is continuous unrelieved pressure, calluses form as a protective barrier, which will eventually lead to ulcer formation.

The goal of biomechanics assessment and intervention is to assist the patient to live a healthy and active lifestyle by providing them with the education and necessary equipment to prevent injury, deformity, and the development of a diabetic foot ulcer. While being physically active plays a vital role in managing diabetes, problems with proprioception make it difficult for patients with diabetes to be safely active. Clinicians should therefore be constantly aware of the need to maintain the patient's activity levels while also compensating for existing deficits with ambulation and proprioception.

The first step is to ensure that the patient has good pedal support and that biomechanical issues are being addressed. This is achieved by preventing postural collapse of the foot. Research shows that custom orthotic supports also help to correct balance, gait, and structural alignment; prevent the occurrence of diabetic foot ulcers; and support treatment for ulcers already present.

The clinician who sees the diabetic patient on a routine basis must be aware of the interaction between biomechanics and preserving the health of the diabetic foot. A consult with a podiatrist should happen early on in the plan of care and at least yearly thereafter. Any new problems related to ambulation and proprioception should also be referred immediately to a podiatrist (Nickerson, 2016).

Addressing Foot Deformities

BUNIONS

A bunion is a protrusion, varying in size, that results from an abnormally prominent fifth metatarsal joint. Bunions can result from wearing tight-fitting, narrow shoes as well as from an inherited structural defect. During a foot exam, the clinician assesses for the presence of a bunion as a medial prominence on the side of the foot. The main treatment is to accommodate the deformity in an expanded shoe and to relieve pressure and shear that could result in wound formation (Edmonds & Foster, 2014).

HAMMERTOES

Hammertoe is a common flexion deformity of the proximal interphalangeal joint of the second, third, fourth, or fifth toes. Hammertoe deformity is also known as *claw toe*, since the affected toes look to be bent in the shape of a claw. It is frequently found in the second toe. Hammertoe deformity is painful and increases the risk of skin breakdown and ulcer formation (Edmonds & Foster, 2014; Driver et al., 2016).

Properly fitting footwear is the most appropriate treatment for this deformity. The clinician ensures that the front of the shoe is sufficiently high to relieve pressure from the hammertoe joints; this may necessitate a consult with the podiatrist. The clinician keeps in mind that when the toes move upward, they draw the soft tissue of the foot pad along with them, which denies the areas at the base of the toes of proper cushioning and increases the risk of callus and ulcer formation in these areas (Scheffler, 2012).

CALLUSES

A callus is a thickening of the epidermis that occurs at the site of pressure on the foot. Shear and friction can also lead to callus formation. The development of a callus is seen as a protective reaction to continued stress on the affected area. Calluses should not be allowed to accumulate, as they are a common precursor to the development of diabetic foot ulcers in patients who have diabetic neuropathy. Excessive callus build-up can increase pressure to that area of the foot by 25% to 35%, and this leads to the development of a diabetic ulcer beneath the callus that the clinician typically cannot see or palpate on examination (Edmonds & Foster, 2014).

Bleeding into the callus is the primary indicator of the presence of an ulcer. When examining an area of callus formation, the clinician looks closely for flecks of blood or the presence of a deeper layer of macerated, white softer tissue under the outer covering of callus. This shows the presence of an evolving ulcer and the need to immediately remove the callus tissue (Edmonds & Foster, 2014).

In most instances, a callus does not cause pain, however pain can be experienced if nerve endings near the surface layers are inflamed (Driver et al., 2016).

The initial treatment for callus is to reduce the bulk with a scalpel while maintaining tension on the skin. Callus removal is done by a podiatrist or a clinician who has experience and training in foot care. Patchy removal of callus tissue can result in focal points of excessively high pressure and increased risk for ulcer development.

Patient education includes stressing that the patient should not attempt to remove the callus themselves (no “bathroom surgery”) and that the use of over-the-counter callus removers is not recommended, since these contain strong acids that may permit infection to gain access to the foot (Edmonds & Foster, 2014).

Callus formation frequently reoccurs and requires close monitoring by the clinician. The biomechanical problem leading to the callus growth must also be addressed to obtain a permanent remedy.

Tight Glycemic Control

Tight glycemic control refers to keeping the blood sugar levels as close to normal as possible. The Diabetes Control and Complications Trial provided strong evidence that keeping blood sugar levels at or near normal levels substantially reduces the chances of developing microvascular complications of diabetes, including diabetic foot ulcers. Preferably, blood glucose levels should be between 70 and 130 mg/dl prior to taking a meal and less than 180 mg/dl two hours after starting a meal (ADA, 2018a).

Poorly controlled blood sugars are a major contributing factor in the development of neuropathy in the extremities of patients with diabetes. High blood sugars also cause impaired leukocyte function, inhibit lymphocytes, and lead to an impaired immune response, which prevents the patient from mounting an adequate response to wound infection (Driver et al., 2016).

The **A1C test** (also called the *hemoglobin A1C* or the *glycohemoglobin test*) is one of the most important tests used in diabetes management and diabetes research. The A1C test examines the binding of glucose to hemoglobin in the red blood cells. Red blood cells normally live for around three months, and by using the A1C test, it is possible to obtain an average of a patient's blood glucose levels over the previous three months.

The A1C blood test result is stated as a percentage. The higher that percentage, the more a patient's blood glucose levels have risen. A normal A1C level is below 5.7%. Prediabetes is diagnosed at readings of 5.7% to 6.4% and diabetes at 6.5% or above. An A1C test can be done at any time of the day and does not require the patient to have been fasting prior to the blood draw (NIDDK, 2014).

Primary care providers help patients to set reasonable goals for blood sugar levels, and this is often done in progressive increments. For a patient whose blood sugar levels have consistently remained high, getting down to the stated normal levels may seem unreasonable. However, it is essential for clinicians to provide encouragement and reiterate that any decrease in blood sugar levels helps to lessen the risk of microvascular complications occurring.

A patient may need to see their primary care provider on a monthly basis when diabetes is first diagnosed and blood sugar levels are being regulated. This also provides an excellent opportunity for ongoing education on foot care. The clinician helps the patient make the connection between blood sugar levels and foot care by explaining that high blood sugar levels cause narrowing and hardening of the arteries, which will decrease the amount of blood reaching the feet. Reinforcement of teaching, reassessment of the patient's ability and commitment to foot care, and encouragement by the clinician are key constituents of successful outcomes.

Weight Loss

Encouraging patients to maintain a healthy weight is another facet of preventive care. One in three adults and close to 17% of children in the United States are overweight, as are many individuals with type 2 diabetes. Being overweight plays a significant role in insulin resistance.

Patients are often doubtful about weight loss and voice fears such as, “I don’t think I can lose a whole lot.” The clinician reassures them that losing even 10 pounds can produce a considerable improvement in blood sugar levels. Most patients will agree that a 10-pound weight loss is doable, and it is then up to the clinician to help them set realistic, specific goals for a weight-loss program.

The patient is typically referred to a registered dietitian for a dietary consultation and to develop a diet program. To achieve maximum success, the diet plan takes into consideration the patient’s lifestyle, food preferences, and the fact that the patient may feel discouraged by previous failed attempts to lose weight. It is important for patients with diabetes to maintain the pleasure of eating, and this is something that the dietitian takes into consideration when assisting the patient to develop meals plans.

Follow-up with the patient is necessary to evaluate progress in meeting goals and to help resolve problems they have encountered.

Smoking Cessation

According to the American Heart Association (2016), around 22% of patients with diabetes are smokers. Smoking places a patient with diabetes at a very high risk for peripheral vascular diseases (in particular, peripheral arterial disease) and the development of diabetic foot ulcers. Cigarette smoking and diabetes are factors in the increased incidence of macrovascular and microvascular disease, in which both the large and small blood vessels are adversely affected (Cypress & Tomky, 2017).

Therefore, as a preventive measure for diabetes complications, patients who smoke must clearly understand the risks of smoking and be encouraged to take part in a smoking cessation program (Edmonds & Foster, 2014). In plain language, the clinician explains to the patient that nicotine narrows the blood vessels. When there is poor circulation to the feet, the skin then becomes dry and can crack easily, and any break in the surface of the skin will potentially allow bacteria to enter and cause an ulcer to develop. Similarly, decreased circulation and oxygen delivery make it harder for an ulcer to heal.

Patients may not find it easy to give up smoking and can be highly resistant to the idea, especially after receiving a new diagnosis of diabetes, when there is a constant demand for lifestyle changes and adjustments. Many times, patients will state that they “need” to continue smoking to cope with the stress of having diabetes. The clinician recognizes this is a subject that may have to be addressed on an ongoing basis over a course of weeks or months.

Until the patient feels ready and committed to stop smoking, there is little that can be achieved.

Once a patient is ready, the clinician helps them decide on a **quitting strategy**, such as stopping all at once, tapering off by cutting down the number of cigarettes smoked each day, using a nicotine patch, joining a smoking cessation program, or receiving acupuncture. Any of these strategies can be used singly or in combination.

Giving up smoking is not easy, and there can be frequent setbacks. Patients may be cranky and irritable, especially during the first few weeks without cigarettes. They require support and encouragement from family, friends, and the clinicians who work with them.

Hypertension Control

Hypertension is one of the main risk factors for the development of microvascular problems in patients with diabetes. Between 2009 and 2012, 71% of patients 18 years and older and diagnosed with diabetes were found to have blood pressures at or above 140/90 mmHg (CDC, 2014). Ideally for patients with diabetes, blood pressure should be maintained at below 130/80 mmHg, with 120/80 mmHg being regarded as a healthy blood pressure.

The patient's blood pressure is checked with each visit, with the patient seated and having rested for approximately 5 minutes. Interventions used to reach target blood pressures first include lifestyle changes. Many patients are also prescribed oral medications, with the first-line recommended treatment being an ACE inhibitor taken daily (Edmonds & Foster, 2014).

Recommended lifestyle modifications include:

- Weight loss
- A diet low in saturated fats and total fat content
- Restricted dietary sodium intake (no more than 2,400 mg/day)
- Regular physical exercise
- Moderate consumption of alcohol (no more than two drinks daily for males and one daily for females)
  (AHA, 2017)

CASE

Mr. Hernandez is a 45-year-old Hispanic man diagnosed with type 2 diabetes one month ago during a routine health check at a local clinic. At that time, he did not have a primary care provider and is being seen today for the first time by a nurse practitioner, Celia. Prior to the appointment, she reviews the patient's chart and notes that Mr. Hernandez was started on Metformin and also has a consult for diabetes education. However, the record indicates that the patient has only attended one session with the certified diabetes educator and missed the subsequent two appointments.

Mr. Hernandez arrives for his appointment accompanied by his wife, who does not speak English. He is polite but reluctant to engage with Celia. He states that he has "no time for diabetes education" and that he is taking his medication as prescribed. He says, "My blood sugars were high because I drink too much soda." When asked about his feet, he replies that they are fine and refuses a foot exam. Celia notes that he is wearing strong work boots and that he has no noticeable problems with his gait.

Celia acknowledges that it's good Mr. Hernandez is having no problems with his feet and explains that this is the best time to start doing routine foot exams. She tells him that diabetes can interfere with the way the nerves in his feet work and that he can slowly lose feeling to areas of his feet without knowing it. This puts him at greater risk for injuring his feet and developing an ulcer. To compensate for the lack of feeling, daily foot checks are critical for protecting his feet from damage. Since Mr. Hernandez has refused a foot exam today, she gives him a handout on diabetic foot care and makes a note to discuss this again at his next visit.

In response to Mr. Hernandez's statement that he has "no time for diabetes education," Celia asks for more information about his work schedule and acknowledges that it can be hard to get time off from work to attend medical appointments. She explains that receiving diabetes education now will help lay out the best course for Mr. Hernandez to follow to control his diabetes and stay healthy, reducing the need for even more future medical appointments. She also offers to look into what other resources are available for diabetes education during the evenings or weekends.

Since Mr. Hernandez already recognizes the link between drinking too much soda and high blood sugars, Celia reinforces the need to monitor blood sugar levels and to reduce his overall sugar intake. They agree on a specific goal of reducing his current soda intake of three cans a day to one can a day, beginning the process of goal setting and gradually making the necessary lifestyle changes.

After Mr. Hernandez and his wife leave, Celia discusses his case with the physician and case manager. She explains that Mr. Hernandez does not seem to have come to terms with the fact that he has diabetes. The physician is concerned that Mr. Hernandez's blood sugars are too high and that he is hypertensive and overweight. He requests the patient be scheduled for a follow-up appointment in four weeks. The case manager also has concerns about Mrs. Hernandez, who has previously conveyed her concern about her husband and that she doesn't understand what is going on or what she needs to do to help him.

Together, Celia, the physician, and the case manager agree that Mr. Hernandez's next appointment will focus on the following:

- Exploring with Mr. Hernandez his feelings about diabetes
- Including a consult with a dietitian
- Recommending a consult with a physical therapist for development of an individualized exercise program

The case manager also states that she will call Mr. Hernandez prior to the visit and get his permission to have a professional interpreter present so that his wife will know what is happening and can share her concerns.
(continues)

DIABETES COMPLICATIONS AND FOOT ULCER PREVENTION

Peripheral neuropathy and Charcot osteoarthropathy (Charcot foot) are two conditions that play a critical role in the development of diabetic foot ulcers, and clinicians must be watchful for the presence of these conditions when working with patients who have diabetes. The early symptoms of Charcot foot are frequently subtle and can easily be missed, with devastating consequences. Therefore, early diagnosis and treatment of these complications is critical in the prevention of DFUs.

Peripheral Neuropathy

Peripheral neuropathy is a condition in which there is damage to the peripheral nervous system, the complex communication network between the central nervous system and the other areas of the body, including the feet. This damage inhibits the regular neurologic activity of the lower extremities. The exact cause of peripheral neuropathy has not yet been clearly defined, but ongoing studies show that it is related to abnormal metabolic actions that can lead to cell injury and nerve ischemia (Edmonds & Foster, 2014).

Peripheral neuropathy is one of the most frequent complications of diabetes and reported to occur in about 50% of patients with diabetes. The International Neuropathic Guidelines define **diabetic peripheral neuropathy** (DPN) as "the presence of symptoms and/or signs of peripheral nerve dysfunction in patients with diabetes after the exclusion of other causes" (Craig et al., 2014).

A 2017 American Diabetes Association (ADA) position statement recognizes DPN as the most prevalent chronic complication of diabetes. It estimates that a minimum of 20% of those with type 1 diabetes develop neuropathies about 20 years postdiagnosis and that neuropathies may already be established in 10% to 15% of those newly diagnosed with type 2 diabetes. New evidence also suggests that a type of painful small-fiber neuropathy may already exist in 10% to 30% of individuals with prediabetes (Pop-Busui et al., 2017).

Peripheral neuropathy is the most common predisposing factor in the development of diabetic foot ulcers, and it has been shown to be present in 78% of patients who have diabetic foot ulcers (Driver et al., 2016). Thus, diagnosis and early intervention of DPN is a critical component in preventing diabetic foot ulcers. The ADA's 2018 Standards of Diabetes Care recommend that patients diagnosed with type 2 diabetes be assessed for DPN at the time of diagnosis and that those diagnosed with type 1 diabetes be first assessed for DPN five years after diagnosis, with follow-up assessments done at least yearly (ADA, 2018a).

DPN normally progresses slowly. It often remains asymptomatic and is detected only with detailed examination. The majority of those affected can be symptom-free, and most patients with diabetes who have DPN are not aware of it (Edmonds & Foster, 2014). It can also be the first presenting symptom of previously undiagnosed diabetes, with tingling and a feeling of numbness being the two major presenting symptoms.

The presence of neuropathy seems to be related to the duration of diabetes and the level of glycemic control. The greater the length of time since diagnosis with diabetes, the greater the likelihood of developing neuropathy. Patients with diabetes who have lower blood sugar levels are found to have better nerve conduction and fewer problems with neuropathy. Research indicates that lowering the hemoglobin A1C levels decreases the complications of DPN (Driver & LeBretton, 2016).

Peripheral neuropathy has a substantial negative impact on the patient's life; it can decrease independence to an extent that patients may not be able to live safely by themselves (Tippett, 2014).

EVALUATING FOOT SENSATION AND REFLEXES

One of the first assessments a clinician performs for every patient with diabetes is to evaluate sensation in the feet. Even if the patient does not present with any of the signs and symptoms of neuropathy, loss of protective sensation may still exist. The clinician explains to the patient that simple, noninvasive testing for foot sensation requires no special preparation on the part of the patient and can be performed in the primary care provider's office or clinic as well as at home.

The American Diabetes Association recommends that all individuals with diabetes have a yearly foot exam that includes screening for diabetic neuropathy. Neuropathy screening should include a 10-monofilament test and at least one additional screening procedure (ADA, 2018a).

The **Semmes-Weinstein monofilament test** is both one of the easiest methods and regarded as the gold standard in evaluating loss of sensation in patients with diabetic peripheral neuropathy. Monofilament testing was first developed in 1899 by Max von Frey using horse hair, which was attached to the inside of a tube. In 1960, psychologists Florence Semmes and Sidney Weinstein made improvements to the original method. Semmes-Weinstein monofilament testing was initially used in leprosy research and later incorporated into standard testing to detect DPN (Craig, 2014).

SEMMES-WEINSTEIN MONOFILAMENT TESTING PROCEDURE

- Choose a quiet and relaxed setting to carry out the testing.
- Help the patient to assume a comfortable supine position, with shoes and socks removed.
- Explain the procedure to the patient and address any questions.
- Show the patient the monofilament and touch their arm or the back of their hand with it, demonstrating a "C" shape. (The Semmes-Weinstein 5.07 monofilament exerts 10 g of force when bowed into this "C" shape and placed against the patient's skin for one second.) This demonstration reassures the patient that the test will not be painful and also allows them to experience the normal sensation they should feel when the monofilament touches different points on their toes and feet.
- Instruct the patient to say yes each time they feel the monofilament touch their toes or feet. (Do not ask the patient "Do you feel that?," since this question may lead the patient to believe that the expected response is yes.)
- Instruct the patient to close their eyes during testing, explaining that this ensures they are feeling the filament rather than seeing it touch their feet. Also instruct the patient to keep their toes pointed straight up during the test.
- Hold the monofilament perpendicular to the patient's skin and, using a smooth motion, press down until the monofilament bends into a "C" shape, holding that position for 1 to 2 seconds before lifting off the filament from the skin surface. The patient should sense the monofilament by the time it bends. If the patient responds yes (that they feel the monofilament), ask the patient whether they feel the pressure on the right or left foot.
- Do not slide the monofilament across the patient's foot or touch either of the patient's feet with one's hands during the testing, so that the only touch that the patient is exposed to is that of the monofilament.
- Apply the monofilament three times to each test site. Also "simulate" one test without applying the monofilament. Avoid repetitive testing at the same site.
- Do not test over areas of callous formation since it is impossible for the patient to accurately determine feeling in those areas.
- For a patient who may already have a diabetic foot ulcer present, test along the margins of the wound and not directly over it.

Protective sensation is intact at each site if the patient correctly responds to 2 out of 3 tests.

Protective sensation has been lost if 2 out of 3 answers are in error.

(Wounds International, 2013)

The **Ipswich Touch Test** (also referred to as the "touch the toes test") is another simple, fast, and easy-to-teach method to detect loss of protective sensation in the diabetic foot. The value of this test is that the clinician can instruct the patient or family members to use it at home in order to monitor the presence or absence of sensation. Studies show that when compared to monofilament testing, the Ipswich Touch Test has good predictive value in detecting loss of protective sensation (Sharma, 2014).

The test is done by lightly and briefly touching the tips of the first and fifth toes of the right foot, followed by the same light, brief touch to the first and fifth toes of the left foot, and finally the third toes of the right and left feet. If the patient does not detect the touch at two or more toes, protective sensation has been lost to a large degree (Edmonds, 2014). However, one Ipswich Touch Test is usually not enough to determine the percentage loss to protective sensation.

Other methods to detect loss of protective sensation include reflex testing, pinprick testing, and vibration perception threshold (VPT) testing.

Reflex testing concentrates on evaluating ankle reflexes, since they are regarded as the most sensitive of the lower extremity reflexes when it comes to screening for neuropathy. To perform reflex testing, the clinician ensures that the ankle is in the neutral position and then strikes the Achilles tendon with the examination hammer. An abnormal finding is present if the ankle plantar flexion response cannot be elicited (Craig, 2014).

Vibratory sense testing can also determine a patient's sensory perception, with a patient's inability to sense vibration from a standard tuning fork being indicative of sensory neuropathy. Studies propose that such loss of vibratory sense often happens prior to a patient's loss of protective sensation and that testing for vibratory sense at the onset of care allows the clinician to discover neuropathy at an earlier stage, when interventions may prove more effective.

The mechanism for vibratory sense testing involves a straightforward procedure using a 128-Hz tuning fork. The clinician strikes the tuning fork on an object or their own hand and then places the tip of the vibrating fork at the patient's first metatarsal bone at the base of each great toe, instructing the patient to indicate when they can no longer feel the vibration. Test results are regarded as abnormal if the patient can no longer feel the vibrations but the clinician can (Varnado, 2016).

Vibration Perception Threshold testing uses a hand-held device that provides quantifiable results and is comparable to testing with a tuning fork. After explaining the procedure to the patient, the clinician places the oscillator flat against the patient's foot, applying only enough force so that the surface of the oscillator makes contact with the skin. The amount of vibration is gradually increased until the patient is aware of it, and at this point the reading on the meter is noted. Testing is not done over areas of calluses or scars but can be done along the margins of existing wounds and necrotic tissue if present (Driver & LeBretton, 2016).

TYPES OF NEUROPATHY

Neuropathy has been broadly classified into three types—sensory, motor, and autonomic—with corresponding characteristics and interventions.

Sensory Neuropathy

Sensory neuropathy leads to the loss of protective sensation, the warning mechanism that lets individuals know that corrective action is needed. When normal sensation is present, feet are immediately removed from danger, but with sensory neuropathy, the awareness of danger is no longer present. For example, a patient may not notice having stepped on a sharp object that has become lodged in the foot or having sustained severe burns by submerging the feet in scalding hot water.

Sensory nerves also conduct messages from the central nervous system to the extremities relating to position. Thus, clinicians may find that patients with DPN have difficulty managing certain movements such as keeping their balance or walking with their eyes closed, which creates a great fall risk for these patients (Varnado, 2016).

Sensory neuropathy frequently begins with numbness and paresthesia (an abnormal sensation of burning or tingling) in the toes and feet and progresses up the patient's leg in what is referred to as a "stocking" pattern of sensory loss. Eventually, the fingers and hands become affected also, with a loss of sensation moving up the arms in a "glove" pattern.

When the clinician examines the patient's feet, they also assess for loss of feeling or sensations of "pins and needles" in the patient's fingers and hands in order to better determine how far the sensory neuropathy has advanced.

Prior to a loss of protective sensation, the patient often experiences several years (in many instances up to 10 years) of painful neuropathy. In its mildest form the patient will refer to these sensations as "pins and needles" or "tingling." As DPN progresses, the patient often describes "burning," "stabbing pain," or "electric shock" feelings. The patient may also complain of itching, heightened sensitivity to generally painless stimuli such as bed sheets on their feet, or an excessive reaction to painful stimuli (Varnado, 2016).

Relief from neuropathy pain comes from movement, and so pain is usually worse at night when the patient is lying down. Patients will complain of interrupted sleep related to neuropathy pain, cramping, restless legs, and the need to move their legs to get relief. The combination of pain and a lack of sleep frequently precipitates exhaustion and depression.

When determining the origin of lower extremity pain in a patient with diabetes, one of the first questions the clinician asks is what relieves the pain? Ischemic leg pain due to poor

arterial circulation is relieved by rest and lowering the extremities (dependent position), whereas neuropathy pain is relieved by the patient getting up and walking around.

Motor Neuropathy

Motor neuropathy is found in the muscles responsible for normal movement of the feet. Distal motor nerves in the foot are most frequently involved, resulting in muscle atrophy (Driver & Lebretton, 2016). Changes in muscle bulk alter the shape of the patient's foot, causing deformities that affect the patient's ability to walk and to bear weight. Over a period of time patients with motor neuropathy can lose up to half of the muscle volume of their feet (Scheffler, 2012).

The visible signs of motor neuropathy are an abnormal gait pattern and irregular weight-bearing that causes areas of excessively high pressure on the soles of the feet. Other signs of motor neuropathy are rigidity in the patient's ankles and toes, which is also related to atrophy of the intrinsic muscles.

The structural deformities that result from motor neuropathy have a major impact on the patient with diabetes, including balance, ambulation, and the heightened risk for ulceration. Some of the main structural deformities that occur are:

- Hammertoe: A flexion deformity resulting in a contracture of the proximal joint of one or more of the smaller toes
- Mallet toe: Similar to a hammertoe, but the flexion contracture occurs at a distal joint in the toe
- Claw toe: A flexion deformity present at both the proximal and distal joints of the toes

When examining the foot of a patient with motor neuropathy, the clinician often finds unusually prominent metatarsal heads and claw toes. These deformities are due to shortening of the Achilles tendon. The disproportionate prominence of the metatarsal heads causes two problems for the patient: abnormal weight-bearing and a high possibility of shear and pressure injury to the metatarsal heads. This can lead to callous formation and the development of foot ulcers. Foot drop is another complication of motor neuropathy (Varnado, 2016).

Autonomic Neuropathy

Autonomic neuropathy is a condition of the autonomic (involuntary) nervous system, which is responsible for the regulation of many body functions such as temperature control, sweating, and the width and tone of blood vessels. Problems with the autonomic nervous system can affect many parts of the body.

A patient with diabetes who develops autonomic loss of control of the sweat glands will present with extremely dry feet, progressing to the development of fissures (either

partial-thickness or full-thickness narrow cracks or openings in the skin). These openings are difficult to treat and keep clean and provide a portal of entry for bacteria, which can result in serious infection. Usually the loss of sweating spreads from the feet up to the patient's knees, and the clinician will notice dry, flaking skin on the lower legs (Edmonds & Foster, 2014).

The deregulation of blood vessels common in autonomic neuropathy leads to continuing dilation of the arteries in the feet because there is a lack of sympathetic innervation, which allows for partial constriction of blood vessels when the feet are at rest (Driver & LeBretton, 2016). During examination, the clinician looks for distended veins over the dorsum of the foot and in the ankle areas. These are a result of arteriovenous shunting, which is a definitive sign of autonomic neuropathy in the feet (Edmonds & Foster, 2014).

TREATING DIABETIC NEUROPATHY

In its position statement on diabetic neuropathy, the ADA emphasizes the importance of screening and early recognition and intervention. The most important interventions in combating all types of neuropathy are tight glycemic control, patient education, and close monitoring for progression of symptoms. In the presence of DPN, daily foot care and inspections become more important. The clinician explains to the patient that once protective sensation is lost, their eyes now become the barrier to injury (Pop-Busui et al., 2017).

Results from the Diabetes Control and Complications Trial demonstrated that **tight glycemic control** slows the advance of neuropathy in patients with type 1 diabetes, but at this time there is no treatment that will restore the loss of sensation (Craig et al., 2014). Tight glucose control has been shown to radically reduce the occurrence of neuropathies in those with type 1 diabetes, with a relative risk reduction of up to 78%. The reduction in patients with type 2 diabetes has been in the modest range of 5% to 9%.

Treatment of diabetic neuropathies also requires the skills of all members of the diabetic foot care team. Neuropathy can lead to a progressive loss of proprioception, weakness, and impaired balance. Unsteady gait and pain can make it increasingly difficult for patients to perform activities of daily living (ADLs). Physical therapists are instrumental in training patients in safe ambulation (possibly with an assistive device), and occupational therapists will provide education in the use of any equipment recommended to assist with ADLs (FPN, 2016).

Treatment for sensory neuropathy includes referring the patient to a neurologist for a detailed evaluation. **Medications** used to treat sensory neuropathy include anticonvulsants gabepentin or pregabalin, antidepressants, neuromodulators, and pain medications, with symptom relief varying from patient to patient. At this time pregabalin and duloxetine, a selective serotonin and norepinephrine reuptake inhibitor antidepressant (SSNRI), have been approved by the U.S. Food and Drug Administration for the treatment of diabetic neuropathic pain.

Some studies have found that treatment with pregabalin and duloxetine have resulted in an improved quality of life for patients with painful diabetic neuropathy. Pregabalin is the drug that has received the most attention, and studies show that it has a positive impact on neuropathic

pain in approximately 30% to 50% of patients, with the therapeutic range for the drug between 150–600 mg/day. In patients 65 years and older, doses are started lower and titrated more slowly (Pop-Busui et al., 2017).

Although opioids have proven effective in treating neuropathic pain, they should **not** be a drug of first choice due to the high risk of addiction, abuse, and sedation. Opioids are recommended only as an "add-on" therapy when all other drug combinations have failed and the patient is referred to a specialized pain clinic for more intensive monitoring (Pop-Busui et al., 2017).

Other interventions include massage, acupuncture, and electromagnetic field (EMF) therapies (Tippett, 2014a). Vitamin supplementation, evening primrose oil, and creams made from capsaicin (an ingredient obtained from hot peppers) are also used to treat sensory neuropathy (Scheffler, 2012). However, patients who have sensitivity or allergies to hot peppers are advised not to use capsaicin cream.

Exercise has been shown to decrease pain related to motor neuropathy and includes a comprehensive program of strength training, exercises to improve balance, flexibility exercises, and aerobic exercises. The physical therapist individualizes the program to match patient needs and may also recommend splints or braces to improve patient balance and posture (FPN, 2016).

Autonomic neuropathy causes a loss of oil production, which contributes to dry, cracked skin. Patients should be advised to apply moisturizing cream or lotion to their feet daily, but not between the toes, which could lead to skin maceration and fungal infection.

Clinicians work with patients to help them find the treatment or combination of treatments that provide the best symptom relief.

Charcot Osteoarthropathy

Charcot osteoarthropathy, frequently referred to as *Charcot foot,* has been described in nonmedical terms as a condition in which the bone crumbles. Charcot causes bone destruction in the affected foot that has been compared to what ensues in osteoporosis (Tippet, 2014b).

Dr. Jean-Martin Charcot, a neurologist, first diagnosed the condition in 1868. It became known as *Charcot's joint*, and in the nineteenth century it was typically found in patients with syphilis. However, in 1936, the condition was also recognized in patients with diabetes (Herscovici, 2016). Type 2 diabetes is now the leading cause of Charcot osteoarthropathy (Moradi, 2014).

Charcot osteoarthropathy is one of the most serious complications of diabetes. Early recognition and prompt and aggressive treatment are necessary to prevent progression of the condition and possible limb amputation. Research shows that patients with diabetes who develop a diabetic foot ulcer and also have Charcot foot run a 12-times greater risk of amputation (Moradi, 2014). Fortunately, greater awareness of the signs and symptoms of Charcot foot has resulted in earlier intervention.

Patients with diabetes who are considered high risk for Charcot foot are those with a longer history of diabetes (usually 10 to 15 years since diagnosis) and those who have developed diabetic peripheral neuropathy. Abnormal activity of the autonomic nervous system with reduced or complete loss of vasomotor control results in an increase in peripheral blood flow and an increase in bone reabsorption. This accelerated reabsorption of bone causes weakening of the bone structure (Armstrong & Lavery, 2016).

Charcot foot many times begins with a slight injury to the joint that may not be noticed by the patient, such as stepping off the curb the "wrong" way, resulting in a minor ankle sprain.

Because the presenting symptoms are similar, Charcot foot is often misdiagnosed as cellulitis and treated with antibiotics, which does not address the underlying condition. This may happen with clinicians who are not familiar with Charcot foot when they observe an extremity that has the classic signs of infection (swelling, redness, pain, and tenderness). However, if the patient has diabetes, these signs should arouse a high suspicion of Charcot foot.

STAGES OF CHARCOT OSTEOARTHROPATHY

Charcot osteoarthropathy has been divided into three stages:

1. Acute or developmental
2. Coalescence
3. Reconstruction
   (Armstrong & Lavery, 2016)

In the **acute phase** of Charcot foot, the patient presents with a foot that is red, swollen, and warm to the touch. The skin temperature of the affected foot is frequently found to be 2 °C greater than that of the nonaffected foot (Edmonds & Foster, 2014).

Foot X-rays may show bone crumbling, but there is also a possibility that X-rays will be normal at this early stage of the condition. A bone scan can be useful in discovering focal areas of bone damage (Edmonds & Foster, 2014). An important sign that the clinician looks for while examining the patient's foot is a decrease or resolution of redness when the foot is elevated (Herscovici, 2016). Other signs that the clinician observes in the early presentation of Charcot disease are:

- Swelling of the foot and ankle on the affected side
- Palpable, bounding pedal pulses
- Diabetic peripheral neuropathy with loss of protective sensation

Laboratory studies typically used to diagnose the presence of infection or an inflammatory process (such as a white blood cell count, C-reactive protein, and serum uric acid) are all normal in the acute stage of Charcot foot (Armstrong & Lavery, 2016). Pulses in the extremity affected with Charcot osteoarthropathy are frequently strong and bounding due to the shunting of the circulation in the foot.

As Charcot foot progresses, pathophysiological changes are more readily seen on X-ray. These changes include deformity, dislocation, partial dislocation of joints, and bone fractures.

The **coalescence stage** is noticeable for repair of the extremity, which involves a decreased swelling of soft tissue, the production of bone callus, and the healing of fractures.

Remodeling of bones takes place in the **reconstruction phase** (Armstrong & Lavery, 2016). This final phase is signified by the occurrence of ankylosis of joints and hypertrophy of involved bones. Clinical findings include the development of a foot deformity, unsteadiness, and abnormal function of the affected joint (Herscovici, 2016). The arch of the foot collapses, with the development of what looks like a "rocker bottom."

Charcot foot can lead to severe deformities that not only alter the patient's gait but also create areas of high pressure on the surface of the foot, prompting the development of a diabetic foot ulcer. The patient with a Charcot foot deformity is four times more likely to develop a diabetic foot ulcer (Driver et al., 2016). During examination of the patient's foot, the clinician looks for significant deformity signifying collapse of the structures of the mid-foot and the development of rocker-bottom foot (Varnado, 2016).

TREATMENT OF CHARCOT FOOT

The appropriate treatment for the patient depends on how far the condition has progressed, the degree of foot deformity present, and which joints are involved. Off-loading and redistributing pressure over the surface of the foot is the cornerstone in the treatment of Charcot foot, preventing the occurrence of diabetic foot ulcers, and healing an existing ulcer (Driver et al., 2016).

The goal of care at this stage is to decrease inflammation, and non-weight-bearing is the best way to achieve this. This involves immobilization of the extremity. Some specialists recommend complete non-weight-bearing on the affected extremity, however numerous studies have shown that weight-bearing in a total contact cast is not harmful to the involved foot.

One of the drawbacks of this treatment is that it can increase the amount of weight-bearing on the opposite limb. When a patient is in total contact casting, the clinician must pay close attention to the noninvolved foot and be alert for developing signs of untoward pressure. The danger of Charcot foot developing in the noninvolved limb of an affected patient is close to 30% (Armstrong & Lavery, 2016).

Surgery is not often performed in patients with Charcot foot, and less than 25% of patients with a Charcot deformity undergo a surgical procedure. However, in some cases, either an external or internal surgical procedure may be done to stabilize the affected joint (Edmonds & Foster, 2014).

Total Contact Casting (TCC)

The total contact cast is applied according to the manufacturer's instructions by a clinician who has been trained in the technique, since an improperly applied or removed

cast can cause unforeseen pressure and lead to ulcer formation. TCC is applied to the whole surface of the foot and usually extends to just below the patient's knee (Varnado, 2016). (See also "Total Contact Casting" later in this course under "Offloading.")

Typically, the first cast is removed one week after placement to allow inspection of the foot. Thereafter, the cast is usually changed every two weeks. Casting and limited weight-bearing will continue until the inflammation has resolved.

During each cast removal the clinician carefully examines the affected foot for signs that indicate a decrease in inflammation, including decreased swelling, redness, and temperature. If a skin thermometer is available, a skin temperature in the affected foot that is within 2 °F of the contralateral limb is regarded as being significant for resolution of inflammation (Varnado, 2016). X-rays of the affected foot should be done on a monthly basis until bone callus consolidation is evident. It can take 12 to 16 weeks to reach this stage of recovery (Bryant & Nix, 2016).

Prefabricated Pneumatic Walking Brace

Not all patients are candidates for total contact casting. The most important consideration is adequate circulation to the extremity. An alternative to TCC is a prefabricated pneumatic walking brace (PPWB) fitted with a custom insole (Edmonds & Foster, 2014).

PPWBs have the advantage that they are easy to remove, have a high satisfaction rating with patients, and have not been associated with any major complications. They are made from a lightweight, partially rigid casing with an inner lining that supports the patient's lower leg on the affected side to a few inches below the knee. They are usually secured in place with buckles and Velcro straps. However, they have limited use in patients with severe foot deformity. A further drawback is patient compliance, since this is a device that can be removed at home (Galhoum & Abd-Ella, 2016).

Postacute Interventions

When the stage of acute inflammation has resolved, total contact casting can be discontinued and the patient fitted for a special brace or footwear to protect the foot. A referral to an orthotist and possibly a pedorthist will be necessary. The goal at this stage is to provide continued stabilization to the foot and ankle while the patient returns to full ambulation. Options for limb protection at this stage include a patellar tendon–bearing brace, specialized shoes with modified ankle-foot-orthosis, or a Charcot restraint orthotic walker (Varnado, 2016).

Assistance from various members of the diabetic foot care team is critical at this stage, especially from the physical therapist and the occupational therapist. The patient will require training on ambulation with the new device, how to correctly put it on and take it off, and how to care for it. Although the specialist who fitted the device will have given the patient instructions, it will be up to other clinicians to reinforce the teaching and to assess for any problems the patient may be encountering with the device.

Ongoing care includes lifetime monitoring of the affected limb, optimum glycemic control, and patient education on the importance of preventing further injury. Once Charcot deformity is present, patients need to be made aware of the increased risk for the development of a diabetic foot ulcer. As well as the regular components of the routine foot checks, the patient should also be taught to check for "hot spots" along their feet and ankles and to inform the clinician immediately if any are detected (Edmonds & Foster, 2014).

CASE *(continued)*

Mr. Hernandez is having his monthly follow-up appointment at the clinic. Since his last appointment, the case manager has spoken with Mr. Hernandez, who agreed to having a translator present so his wife will be fully aware of what is going on. As well as seeing the nurse practitioner today, Mr. Hernandez will meet with the RN and physical therapist.

Mr. Hernandez is happy to share his good news with the team: he has lost 6 pounds since his last visit, which he attributes to the fact that he has stopped drinking sodas. The team congratulates him on his success as well as on the slight drop in his daily blood sugar readings. It is obvious from his demeanor that losing weight has had a positive impact on Mr. Hernandez's attitude toward his condition, and Mrs. Hernandez asks what she can do to help her husband lose even more weight.

The RN reviews his family history with Mr. Hernandez and asks for more detail about his mother's kidney disease. As she suspected, his mother had been a diabetic for many years prior to developing kidney disease. The RN explores with Mr. Hernandez what this meant to him, and he admitted that he had a deep fear the same would happen to him. His mother's diabetes was poorly controlled, and he believed this was the same for all patients with diabetes. Both the RN and physical therapist spend time explaining to Mr. Hernandez and his wife (via the translator) that diabetes can be controlled.

Mr. Hernandez agrees to a foot exam. A Weinstein-Semmes monofilament exam indicates that Mr. Hernandez has diabetic peripheral neuropathy in both feet, with his left foot more severely affected. There is also a noticeable deformity of his left foot, with increased temperature around the dorsal surface and ankle areas compared to the contralateral limb and increased redness on the plantar surface of the left foot along the base of the metatarsal heads. Mr. Hernandez states that it's "impossible" for him to take time off from work and that, "although my left foot is a bit red, it feels fine."

An X-ray ordered by the NP is normal, but the team is concerned that Mr. Hernandez is developing early-onset Charcot osteoarthropathy. When Mr. Hernandez entered the exam room, the physical therapist noted a slight deviation in his gait that propels him more to his left side. The physical therapist examines his footwear, which are strong leather work boots with a reinforced toe area. The toe-box is sufficiently deep to accommodate the foot, but the insole is hard and rigid from excessive wear. As a roofer, Mr. Hernandez states that this is the only type of footwear he is allowed to wear at work.

Mr. Hernandez has signs of early Charcot foot, which is a serious complication. Given that he cannot take time off from work, the team must develop suitable strategies to protect his feet from further damage. Ideally, he should be non-weight-bearing to his left foot, but since this is not a practical solution, the next best alternative is to schedule an immediate consultation with an orthotist. The physical therapist believes there is sufficient room in Mr. Hernandez's boots for a specially fitted insole to help relieve pressure. The physical therapist also gives Mr. Hernandez a written list of recommendations to use when he is not at work, including wearing seamless socks and cushioned slippers and resting with his feet elevated.

The RN and the physical therapist must also respond to Mr. Hernandez's statement that his left foot "feels fine." Like many other patients with diabetes, Mr. Hernandez finds it hard to believe there could be anything seriously wrong with his foot since he feels no pain. The results of the monofilament testing are explained carefully to the patient. The nurse tells him that he feels no pain because he has lost sensation to several parts of his left foot; but he is probably not aware of this because other areas of his foot still have sensation. Techniques on preventing injury to his feet, including a daily foot exam, need to be taught to Mr. Hernandez and his wife (if he agrees) and reinforced at every follow-up visit. They will need written educational materials in both English and Spanish.

In response to Mrs. Hernandez's question about helping her husband continue to lose weight, the team believes a good place for her to start is with a review of their food intake. They reinforce the positive results she has noticed from her husband's lower weight and his willingness to continue this effort. The case manager indicates that she will identify community resources where Mrs. Hernandez can learn about meal planning and healthy cooking for a person with diabetes.

As the appointment ends, the NP arranges to see Mr. Hernandez back in the clinic in two weeks. During that time, the physical therapist will work closely with the orthotist on securing pressure relieving customizations to Mr. Hernandez's existing footwear.
(continues)

Diabetic ulcer on the plantar surface of patient's foot.
(Source: Illustration by Jason McAlexander. © Wild Iris Medical Education.)

ASSESSMENT OF PATIENTS WITH DIABETIC FOOT ULCERS

Patients who present with a diabetic foot ulcer require holistic assessment that includes:

- Physical assessment of the wound
- Wound history
- Neuropathy assessment (discussed earlier in this course)
- Peripheral arterial disease assessment
- Ankle-brachial assessment
- Infection assessment
- Classification of the wound

One of the main goals of assessment is to identify the underlying cause of the diabetic foot ulcer and to make every effort to either correct it or remove it.

Physical Assessment of the Wound

Physical assessment begins with inspecting and comparing both feet for structural changes, pressure points, location, and other wound characteristics.

Structural change. Structural changes such as collapse of the arches of the foot and a rocker-bottom appearance on the plantar surface of the foot are frequently found on examination (see also "Diabetes Complications" earlier in this course).

Pressure points. Areas of increased redness may be observed in comparison to surrounding tissue.

Wound location. The location of an ulcer helps to determine the cause and the most appropriate method of relieving pressure (Armstrong & Lavery, 2016). Diabetic ulcers can occur on any part of the foot. The most common locations are over the dorsal aspects of the toes and on the plantar surface of prominent metatarsal heads. Ulcers also frequently occur along the margins of the foot over bony prominences (Edmonds & Foster, 2014). Other sites for the development of diabetic foot ulcers are:

- Toe-webs, often the result of increased moisture, footwear that is too narrow, toe crowding, and toe deformities
- Over bunions, where there is increased pressure from shoes that do not fit correctly
- Distal ends of the toes, which indicate that there is poor arterial circulation
- Plantar surface of the mid-foot area, a common site for diabetic foot ulcers when a Charcot foot deformity is present
- Heels, often starting as deep, narrow fissures
  (Armstrong & Lavery, 2016)

Shape. Diabetic foot ulcers are frequently round or oblong in shape.

Size. Initially, it may be hard to determine the size of the ulcer. In many cases, foot ulcers are covered with a layer of callous, and the true size cannot be determined until that is removed. The size of the wound is measured in centimeters using a plastic or paper disposable ruler. Methods for obtaining measurements include:

- Measure the longest part of the wound and the widest part of the wound perpendicular to the length.
- Use the face of a clock to represent the patient's body and describe the wound's orientation, with the patient's head being at the 12 o'clock position and feet at 6 o'clock. The width of the wound is then stated as the distance from 3 o'clock to 9 o'clock.

Depth. Wound depth can range from partial thickness, where only the upper layers of tissues of the epidermis and dermis are involved, to full thickness, extending farther to deep bone

structures. At initial view, the wound may appear to be a small, shallow surface wound; however on further examination and probing of the wound, hidden depths may be found, along with sinus tracts extending down to bone. The depth of the wound is assessed by gently inserting a sterile cotton-tipped applicator into the wound until it reaches the bottom; a mark is made on the applicator parallel to the wound surface; and the applicator is then gently removed and the depth measured with a disposable centimeter ruler.

Wound base. Depending on its depth, the wound base can vary from pink to pale red for wounds that are shallow. Sometimes, it may not be possible to visualize the base of the wound, especially in the case of deep wounds that extend down to bone or where necrotic tissue is covering the base.

Undermining/tunneling. Undermining is the loss of tissue under intact skin surfaces, frequently extending a short distance from the wound. Tunneling is a tract that continues from the surface of the wound down through the underlying tissues; it is also referred to as a *sinus tract.* These wound characteristics can be measured and documented using the clock-face method (see above), i.e., "undermining for 2 cm from 8 o'clock to 12 o'clock, with the greatest depth of 3 cm." Tunneling is measured by gently inserting a sterile cotton tip applicator to measure the depth of the wound (see above).

Wound edges. In diabetic foot ulcers the edges of the wound are usually well defined. Undermining may or may not be present. When assessing the wound edges, the clinician observes whether the wound edges are open and proliferative; such edges indicate a potential to assist with wound healing by facilitating cell migration across the wound bed, whereas edges that are closed and rolled under prevent the wound from closing. With diabetic foot ulcers, it is not unusual to find hyperkeratosis, a callus-like tissue that forms around the edges of the wound and causes them to become hard and thickened.

Periwound area. Callus formation frequently extends into the periwound area in diabetic foot ulcers. Other findings in the periwound area may be erythema, induration, and maceration, which indicate possible infection.

Exudate. Exudate, or drainage, can range from small to large amounts. The amount of drainage in diabetic foot ulcers is usually small to moderate. However, where infection or other disease conditions are present, such as heart disease, renal disease, or venous insufficiency, the amount of drainage can be large. Drainage from diabetic foot ulcers is usually clear or serous. The presence of purulent drainage with a foul odor is indicative of infection.

Type of tissue present. The type of tissue found in diabetic foot ulcers can vary from pink nonviable tissue to slough and necrotic tissue. Slough is a thin, stringy, or mucous-like substance that is yellow or tan in color and either loosely or firmly attached to the wound. Necrotic tissue is dead, devitalized tissue that is black or brown in color and usually firmly attached to the wound base. It is common for diabetic foot ulcers to have more than one type of tissue present in the wound. Exposed bone is also a critical finding in a diabetic ulcer and requires immediate attention (Bates-Jensen, 2016; Varnado, 2016). (See also "Osteomyelitis" later in this course.)

Wound History

Another essential step in assessing a foot ulcer is obtaining a complete history, especially if this is the first time the clinician has seen the patient. (See also "Health and Family History" earlier in this course.)

Questions at this stage include:

- How long has the ulcer been there?
- Has the patient had previous foot ulcers and in what locations?
- Is the patient aware of precipitating circumstances that led to the ulcer development?
- Is there pain associated with the ulcer?
- What tests and treatments has the patient had in the past, and what is the current status of their wound care? How successful does the patient rate the treatments received?
- What is the patient's perception of the seriousness of the ulcer?
- How has the ulcer affected the patient's activities (i.e., work, recreation, hobbies)? Does it affect the amount and quality of sleep? How has it impacted relationships with loved ones, friends, and coworkers?
- What are the patient's goals for treatment? Is the patient able and willing to commit to the time and effort necessary to achieve healing?
- What support does the patient have? Who can provide help with wound care, keeping appointments, and travel, if needed? What type of health coverage does the patient have? Is the patient aware of community resources and used them in the past?
- Does the patient have coexistent health conditions?
- Is the patient taking any medications, including prescription, over-the-counter, and herbal/naturopathic substances?
- Does the patient smoke, and if so, how many cigarettes daily? Does the patient drink alcohol and how much? Use any illicit drugs?
- What other healthcare providers does the patient see, and how frequently? The clinician ensures that the patient's diabetes care team has access to all of the patient's records from other providers so that these can be fully reviewed. This may necessitate getting the patient's written consent for release of records from other providers.

Infection Assessment

It is essential that infection in a diabetic foot ulcer is recognized early and treated. Every patient with diabetes who presents with a foot ulcer must be thoroughly assessed for infection. This can

prevent a mild infection from progressing to a more critical stage. A 24-hour delay in recognizing and treating severe infection in a diabetic foot ulcer can result in irreparable damage (Edmonds & Foster, 2014). Over 55% of diabetic foot ulcers become infected, and about 20% of patients with ulcer infection end up having a lower extremity amputation (Wounds International, 2013).

Detecting infection in a diabetic foot ulcer can be challenging. The patient's temperature and white blood cell count are often normal. Studies show that no more than 50% of severe infections in diabetic foot ulcers result in elevation of white cell count. An elevated temperature is usually an indication that the infection has spread into the deep spaces of the foot.

Research indicates that changes in the serum CRP (C-reactive protein) level is an accurate gauge of the extent of infection in diabetic foot ulcers. A CRP level greater than 200 mmol/L is a marker for severe infection from either the presence of bacteria or widespread tissue destruction, which indicates the need for surgical debridement (Edmonds & Foster, 2014).

Patients with diabetes who have an undiagnosed ulcer infection may complain of feeling generally unwell, and there is frequently a sudden spike in blood sugar levels even though the patient has not made any changes to diet or activity level.

In patients with diabetic neuropathy, pain is often not a finding, and so the patient will not complain of pain in the wound or surrounding tissues.

The most common early presenting sign of infection in the diabetic foot ulcer is cellulitis, which is an infection of the surrounding subcutaneous tissue and skin. The area of infection will be red and hot to the touch; swelling and hardness of tissue may also be present.

Other more subtle signs of infection are friable (disintegrates easily) granulation tissue in the wound, undermining in the wound, large amounts of wound drainage, and a malodor that persists after the wound is cleaned.

Severe, deep infection within the wound is often indicated by purplish-blue discoloration in the tissues extending beyond the ulcer. This discoloration results from diminished oxygen supply to the tissues and the increased metabolic demands of infection. Beneath this discolored skin surface there can be extensive destruction of subcutaneous tissue and fascia. These ulcers require surgical debridement to remove devitalized tissue and to accurately assess the depth and extent of the tissue destruction (Edmonds & Foster, 2014).

Taking cultures from a diabetic foot ulcer to check for infection is recommended if slough and necrotic tissue remain present after the wound has been surgically debrided. All open wounds are colonized with organisms, and this colonization will intensify if devitalized tissue is present.

The technique used for obtaining cultures is important to distinguish between colonization and infection. To get the most accurate results, the culture is obtained either by biopsy from the debrided wound base or by aspirating tissue fluids. Tissue biopsy is done by removing a small piece of tissue from the ulcer base using a sterile scalpel and forceps. To obtain a fluid sample, a

sterile needle is inserted into the tissues adjacent to the ulcer and fluids are then aspirated. This procedure is done by a physician or a trained and licensed clinician (Bryant & Nix, 2016).

The presence of widespread inflammation and crepitus (a grating sound heard when the area adjacent to the wound bed is palpitated) are indicators of deep wound infection. Crepitus is caused by the presence of air in the subcutaneous tissues. Gangrene is another sign that is highly suggestive of a severe infection in the affected foot. These patients need immediate referral to a surgeon who is experienced in diabetic foot care (Wounds International, 2013).

Osteomyelitis (infection in the bone) is a common finding in diabetic foot ulcers, especially in patients with moderately to severely infected diabetic ulcers (Wounds International, 2013). Osteomyelitis is found in around 60% of these patients and is caused by the spread of the infection from the ulcer to the bone (Bryant & Nix, 2016).

(See also "Treating Infection" later in this course.)

LIMB-THREATENING INFECTION?

Diabetic foot infections are seen as either non-limb-threatening or limb-threatening. The characteristics of **non-limb-threatening infection** are:

- Cellulitis that is <2 cm circumferentially
- No signs of systemic infection
- No deep abscess, osteomyelitis, or gangrene present

The characteristics of a **limb-threatening infection** are:

- Cellulitis around the wound that extends beyond 2 cm
- Signs of systemic infection (a temperature >98.6 °F is an important finding in a patient with a diabetic foot ulcer)
- Presence of a deep abscess, osteomyelitis, or gangrene

(Bryant & Nix, 2016)

Classification of Diabetic Foot Ulcers

Classification systems for diabetic foot ulcers have been developed to aid clinicians in organizing and relating assessment data regarding diabetic foot ulcers. Referring to the wound simply as a "diabetic foot ulcer" was considered too vague and did not provide concrete information from which to develop a treatment plan or determine a prognosis (Armstrong & Lavery, 2016). Classification systems have helped to provide a consistent approach to treatment and a common language that facilitates better communication among providers (WOCN, 2016). For any classification system to be meaningful, it must be used consistently by all members of

the wound care team, with appropriate documentation in the patient's records (International Best Practice, 2013).

Classification systems grade ulcers according to the presence and extent of several physical traits, namely, the location, size, depth, and appearance of the ulcer. The two mostly widely used are the Wagner System and the University of Texas Diabetic Foot Classification System.

WAGNER SYSTEM

The Wagner System was initially developed in the 1970s as a guideline for the level of surgical intervention. However, it is now a widely used system to determine the severity of the diabetic foot ulcer and to guide overall treatment. The Wagner System is centered on three components of the diabetic foot ulcer:

- Ulceration
- Infection
- Ischemia

It then divides the diabetic foot ulcer into six different grades, 0 to 5.

WAGNER CLASSIFICATION SYSTEM

Grade	Description
0	No open areas, or a history of a previous healed ulcer
1	Superficial ulcer
2	Exposed deep structures such as tendon or bone
3	Abscess or osteomyelitis detected in deep tissues
4	Wet or dry gangrene present on the toes or part of the forefoot; infection present or not present
5	Gangrene encompassing the entire foot

Source: Herscovici, 2016.

The original Wagner System did not incorporate the presence of infection, ischemia or neuropathy in the assessment tool. In 2012 the tool was revised by the Wound, Ostomy and Continence Nurses Society (WOCN), which added ischemia and infection to the grading system (Driver et al., 2016).

UNIVERSITY OF TEXAS CLASSIFICATION SYSTEM

The University of Texas Diabetic Foot Ulcer Classification System uses grades and staging to classify diabetic foot ulcers. This system is seen as an improvement on the Wagner System, has been well validated, and is regarded as an accurate predictor of patient outcomes. Grades denote the depth of the wound and staging signifies complications that impede healing, in particular

infection and ischemia (WOCN, 2016). The depth grade ranges from 0 to 3 as described in the table below.

UNIVERSITY OF TEXAS CLASSIFICATION SYSTEM	
Grade	**Depth**
0	No open area present
1	Presence of a superficial full-thickness or partial-thickness ulcer
2	Presence of a deep wound that includes tendon or joint capsule
3	A wound that is down to bone
Stage	**Infection/Ischemia**
A	No infection present
B	Wound infection present, but not ischemic
C	Ischemia present, but no infection
D	Ischemia and infection both present
Source: Herscovici, 2016.	

PEDIS SYSTEM

The PEDIS system was developed by the International Working Group on Diabetic Foot Ulcers as a user-friendly classification system for clinicians who are new to diabetic foot ulcer management. It looks at four different factors to assess the severity of the ulcer:

- Perfusion status
- Extent (size of the wound)
- Depth (amount of tissue lost)
- Infection and sensation (presence of neuropathy)
  (International Best Practice, 2013)

MANAGEMENT OF THE DIABETIC FOOT ULCER

The development of a diabetic foot ulcer is a significant progression for the patient with diabetes. Many times the patient is not seen by the wound care team until a diabetic foot ulcer is already present, and patient education must be provided in the midst of a great deal of other interventions. The patient may feel overwhelmed and lack the capacity to grasp all the new information. In such a case, the clinician focuses on creating a supportive relationship with the patient. Treatment goals, management strategies, and obstacles that the patient encounters are explored, and solutions that are workable for the patient are put in place.

Once a diabetic foot ulcer has developed there are two important goals: 1) healing the existing ulcer and 2) preventing further ulcers from developing. A history of a prior diabetic foot ulcer is the greatest risk factor for developing further ulceration. Studies indicate that around 70% of patients with a healed diabetic foot ulcer will develop a new ulcer within five years (Scheffler, 2012).

In order to achieve the goal of wound healing and complete wound closure, interventions must be started early and aggressively applied. Several interventions will be happening simultaneously, for example, infection control, assessing for adequate blood supply to the affected extremity, wound care, and off-loading.

It is a highly stressful time for patients and families, who can have a hard time keeping up with all that is going on, meeting new providers, the possibility of information overload, and having to make rapid decisions, plus the very real fear of losing a limb. The support of the wound care team is of paramount importance at this time, and patients will often rely on clinicians that they are most familiar with to help them understand what is happening and guide them in making decisions. Therefore, it is important that in the frenzy of activity, the clinician makes quiet time to be with the patient as an individual and to simply ask, “How are you doing?”

Diabetes Management

To achieve healing of the diabetic foot ulcer, the wound care team must concurrently address optimal diabetes control, with the primary focus on tight glycemic control and managing risk factors such as hypertension, hyperlipidemia, and smoking. A nutritional evaluation should also be performed and any nutritional deficiencies corrected.

If the patient’s footwear has not been examined previously, a footwear assessment is done at this stage. If possible, the clinician exams the footwear that the patient wears to work and when going out as well as the slippers or other footwear worn while at home. If the patient is not yet in the habit of checking their footwear, the clinician instructs them in this important step, stressing the importance of examining all footwear for the presence of foreign bodies that may cause irritation and trauma to the patient’s foot (e.g., pebbles, small pieces of glass, straight pins, small needles, even pet hairs) (Wound International, 2013).

Vascularization of the Affected Limb

An ulcer will not heal without an adequate blood supply regardless of what other interventions are put in place. Studies indicate that 30% of patients with diabetes who have lower extremity neuropathic disease also have coexisting peripheral arterial disease (WOCN, 2016). The essential elements of a vascular assessment include:

Inspection of the skin, hair, and nails of both lower extremities, to determine if atrophic changes are present. The clinician looks for skin that is pale in color, thin, and shiny. However, the clinician is aware that the feet can be red and warm to the touch even in the presence of severe ischemia. This results from a high shunt blood flow due to autonomic neuropathy (Armstrong & Lavery, 2016). Also notable is a lack of hair growth on the lower extremities that

is not typical for the patient, i.e., the patient may state, "I used to have a lot of hair, even on my toes, but not anymore." Ridged toenails may also be present.

Venous refill time. Prolonged venous refill time of >20 seconds and prolonged capillary refill of >3 seconds indicates decreased perfusion to the extremity.

Palpitation of lower extremity pulses (the dorsalis pedal pulse, located on the dorsal surface of the foot, and the posterior tibialis pulse, found below and behind the medial malleolus). If the clinician is unable to palpate pulses, a handheld Doppler probe is used. Diminished or absent pulses require further testing and a probable consult to a vascular specialist. However, vascular insufficiency cannot be determined solely on the absence of pulses; some people lack one or both pulses and still have normal circulation, whereas many people with vascular insufficiency have normal pulses (WOCN, 2016).

Assessment of ankle-brachial index (ABI). This is a simple, indirect test of lower extremity perfusion done by the clinician in the clinic. It is one of the most frequently used noninvasive tests of lower extremity circulation. ABI is measured by comparing pressures in the upper extremities with those in the lower extremities.

OBTAINING AN ABI

The procedure for obtaining an ABI is as follows:

- Have the patient rest supine in a quiet, comfortable environment for about 10 minutes before starting the test.
- Explain the procedure to the patient and begin by measuring the brachial pressures in each upper extremity using a standard blood pressure cuff that is the appropriate size for the patient, a Doppler probe, and transmission gel.
- Place transmission gel over the pulse site, and inflate the cuff to about 20–30 mm higher than the last sound heard.
- Place the tip of the Doppler probe pointing toward the patient's head at a 45-degree angle and slowly deflate the cuff until the first sound is detected. This is then recorded as the systolic pressure and the procedure repeated in the opposite extremity.
- Place an appropriately fitting cuff around the lower leg about 3 cm above the malleolus, and follow the same procedure as above for obtaining the pulses. In this instance the tip of the Doppler probe is at a 45-degree angle pointing toward the patient's knee.
- Measure the dorsalis pedis and the posterior tibialis pulses in both lower extremities.

The ABI is calculated by dividing the higher of the dorsalis pedis or the posterior tibialis pressure for each lower extremity by the higher of the right or left upper extremity systolic pressure. An ABI reading of 1.0 is considered normal (WOCN, 2016). However, arteries in the

lower extremities can become less compressible due to diabetes, and this can result in ABI readings of >1.1–1.3. These results are abnormal and can be found in approximately one third of all patients with diabetes. Abnormal ABI results must be followed up with more extensive testing. ABI testing is done in the imaging department, where Doppler waveform patterns will be available and provide a more accurate picture of blood flow to the lower extremities.

Indications for revascularization include not only critical limb ischemia but any situation in which there is evidence of decreased or impaired circulation. It is important for the clinician to keep in mind that adequate perfusion is essential to achieve healing and to prevent or delay a future amputation. The recommendation is that all patients who present with critical limb ischemia, an existing diabetic foot ulcer, and rest pain be referred to a vascular surgeon for evaluation of arterial reconstruction (International Best Practice, 2013).

Although the rate of lower extremity amputations caused by infection has remained steady, the rate of amputations related to peripheral vascular disease has decreased tenfold in the United States over the past ten years. This drop is accredited to the development of endovascular surgical techniques that permit arterial inflow surgery to be extended distally with fewer complications (Herscovici, 2016).

The vascular status of the affected extremity must always be determined before proceeding to sharp debridement of the ulcer. Prior to performing extensive sharp debridement, a consult to the vascular surgeon maybe warranted, and revascularization done if appropriate to prevent damage to tissues that already have poor circulation (International Best Practice, 2013). However, if there is wet gangrene or abscess formation in the ulcer, debridement is performed immediately, and this is usually done in surgery. Revascularization of the affected leg is attempted as soon as possible after the surgical debridement. Depending on the type of revascularization procedure, the timeframe to achieve maximum blood circulation to the foot can range from a few days to up to four weeks (Armstrong & Lavery, 2016).

Wound Care

Wound care for diabetic foot ulcers focuses on the steps listed below to create the optimum environment for wound healing:

- Radical and repeated debridement of the wound to remove all necrotic tissue
- Frequent wound inspection and assessment
- Bacterial control
- Attention to maintaining moisture balance to optimize healing
- Supporting epithelial edge advancement
- Optimal dressing selection
  (WOCN, 2016)

DEBRIDEMENT

Wound and callous debridement is an essential part of diabetic foot care. For diabetic foot ulcers the gold standard for debridement is regular, local, sharp surgical debridement performed by a licensed and trained provider using a scalpel, scissors, and/or forceps. The benefits of debridement include:

- Removes necrotic tissue and callus
- Clears bacteria from the wound bed
- Disrupts biofilm
- Stimulates the production of growth factors
- Reduces pressure
- Allows for full inspection of the underlying wound tissues
- Facilitates the drainage of secretions from the wound
- Enhances the effectiveness of topical preparations
- Stimulates healing
  (Bryant & Nix, 2016; Wound International, 2013)

The need for debridement must be discussed with the patient, and the clinician ensures that the patient understands the procedure before obtaining their written consent to proceed. The **goal** of debridement is to remove all devitalized tissue, callus, and foreign bodies down to the level where viable bleeding tissue is found. It is necessary also to debride the wound edges to permit epithelial edge advancement, which allows the epithelium to migrate across a firm, level base of granulation (Wound International, 2013).

The requirement for further debridement is determined at each dressing change. Studies show that serial debridement of diabetic foot ulcers for the first four weeks of treatment has decreased the median wound area by at least 54% compared to ulcers that do not undergo debridement. Serial debridement is usually done on a weekly basis and is referred to as *maintenance debridement* (Bryant &Nix, 2016).

More than one type of debridement may be necessary to completely debride a diabetic foot ulcer. The type(s) of debridement used are dependent on several factors:

- The status of arterial circulation to the extremity
- Current medications (e.g., anti-embolic, which would increase the risk of bleeding)
- Pain in the wound and/or surrounding tissues
- Clinical setting (outpatient, day surgery or inpatient)
  (Bryant & Nix, 2016)

TYPES OF DEBRIDEMENT		
Name	**Mechanism of Action**	**Advantages**
Conservative sharp debridement	Loosely connected necrotic tissue is removed from the wound bed using sterile scissors or scalpel and forceps.	Quick and safe way to remove dead tissue
Enzymatic debridement (collagenase)	Collagenase dissolves the collagen bonds that secure necrotic tissue to the wound bed.	Used when surgical debridement is not feasible, i.e., a patient on anticoagulant therapy with a risk of bleeding
Autolytic debridement	A natural form of debridement, it utilizes the body's own white blood cells to clear necrotic tissue from the wound.	Safe, although slow
Biological/bio-surgical debridement (maggot therapy)	Maggot larvae produce a mixture of enzymes and broad-spectrum antimicrobials to remove necrotic tissue from the wound bed.	Faster than autolytic or enzymatic debridement
Source: Mamou & Katz, 2016.		

DRESSING SELECTION

There is no evidence to show that any one particular dressing works better for diabetic foot ulcers than other dressings. Dressing selection for diabetic foot ulcers is based on the principles of moist wound healing, management of wound drainage, ensuring a moist wound surface, and protection of the periwound area (WOCN, 2016).

When choosing a dressing, the following factors are taken into consideration:

- What are the wound characteristics (size, depth, amount of drainage, etc.)?
- What type of tissue is present in the wound bed?
- What is the condition of the periwound area?
- Can the dressing manage the amount of drainage from the wound and prevent maceration of the periwound area?
- Will the dressing be applied to the plantar surface of the foot and will it have to fit over or between toes?
- Is the dressing easy to apply?
- Does the dressing remain intact and stay in place during wear time?
- What is the frequency of dressing changes?

- Will the dressing prevent wound trauma and pain during dressing changes?
- What type of off-loading device will the patient be using and will the bulk of the dressing accommodate the off-loading device?
- Is the dressing cost effective?
  (Wounds International, 2013)

General rules for selecting dressings are as follows:

- For dry necrotic wounds, select a dressing that will rehydrate the wound and help to soften the eschar.
- For ulcers where slough and moisture are present, choose a dressing that will control moisture and help to debride the devitalized tissue.
- Where wound infection is present, consider an antimicrobial dressing to decrease the wound bioburden and manage wound drainage.
- For newly forming granulation tissue in the wound, select a dressing that will protect the new tissue growth.

Dressings designed to be left in place for more than five days are not considered a good choice for treatment since diabetic foot ulcers must be inspected and assessed frequently.

SUMMARY OF WOUND DRESSINGS		
Type (description)	**Indications for Use**	**Advantages**
Alginates (absorbent, made from light seaweed)	In moderately to heavily draining wounds	• Can stay in the wound for up to 72 hours • Flat and rope dressings available • Silver impregnated available
Hydrocolloids (occlusive)	For autolytic debridement; to protect periwound area from trauma and drainage; not for use in heavily draining wounds	• Simple to apply • Wide range of sizes and shapes • Conform to wounds on most parts of the body
Hydrogels (hydrating; donate water to the wound bed)	In shallow wounds with scant drainage	• Cost effective • Easy to apply; helps with pain management • Promote autolytic debridement
Hydrofiber (absorbent; made from carboxymethylcellulose)	In moderately to heavily draining wounds	• Will not adhere to wound bed • Available in plain and antimicrobial forms

Foam (absorbent, can be adhesive or nonadhesive)	In moderately to heavily draining wounds; but problematic with off-loading devices if bulky	• Highly versatile; reduce wound pain • Available with adhesive borders
Composite (combination)	To provide adhesion, absorption of wound drainage, and protective barrier against bacterial infection	• Easy to apply and remove • Can be used in conjunction with other topical wound therapies such as medications applied to the wound bed
Contact layer (nonadherent layers placed directly onto wound bed)	To allow drainage to pass through to absorptive dressing above	• Protect the wound from trauma • Help maintain a moist wound environment • Protect newly forming granulation tissue
Antimicrobial (cadexomer iodine, silver, honey, hydrofera blue)	Against a broad spectrum of microorganisms that cause wound infection and biofilm formation	• Help reduce wound odor • Easily removed; decrease discomfort during dressing changes
Collagen (derived from type 1 bovine, avian, or type 3 porcine collagens)	To stabilize the chemical balance in the wound by decreasing the level of proteases, which destroy the newly forming collagen fibers in the wound bed	• Easy to apply • Help maintain a moist wound environment • Can be used with topical wound agents
Source: Mamou & Katz, 2016.		

ANTIMICROBIAL TREATMENT

Topical antimicrobial agents are frequently used in the treatment of infected diabetic foot ulcers. A short course of antimicrobial treatment is recommended to reduce the bacterial load and protect the ulcer from further contamination. Wounds treated with antimicrobials for an extended period of time may develop resistant organisms (Bryant & Nix, 2016).

An initial two-week treatment with antimicrobials is recommended. If after two weeks the wound has improved but there are still signs of continuing infection, the wound care team may consider it clinically appropriate to continue the antimicrobial for a longer period treatment with regular reassessment. Once the signs of infection are no longer present, the antimicrobial treatment is discontinued and the wound reevaluated for the most suitable dressing to apply at this stage.

If after two weeks of antimicrobial treatment the wound shows no signs of improvement, the antimicrobial therapy is discontinued and the current treatment plan is reevaluated. The wound care team ensures that all underlying causes that impede healing have been addressed and are being adequately dealt with. The team also closely reassesses the patient's understanding and compliance with the treatment plan (Wound International, 2013).

Topical antimicrobials regularly used in the management of diabetic foot ulcers are listed in the following table:

TOPICAL ANTIMICROBIALS		
Name	**Description**	**Comments**
Cadexomer iodine	• Effective against methicillin-resistant *Staphylococcus aureus* (MRSA) • Decreases bacterial load • Secondary dressing required	• Patient must not be allergic to iodine • Not to be used in dry wounds • Nontoxic to fibroblasts in the wound bed
Medical-grade honey	• Broad-spectrum antibacterial action • Releases anti-inflammatory substances into the wound • Assists with autolytic and mechanical wound debridement	Patient must not be allergic to honey, bee products, and bee stings
Silver	• Broad-spectrum antibacterial action • Effective against Gram-positive and Gram-negative organisms	Efficiency depends on the rate of release of ionic silver into the wound
Source: Mamou & Katz, 2016.		

DRESSING CHANGES AND WOUND MONITORING

Regular monitoring of the patient's wound and dressing is essential. For wounds that are infected, the clinician assesses the wound and changes the dressing daily. Assessment includes monitoring the status of the wound for indications that the wound is progressing, which may be characterized by the following features:

- Decrease in wound dimensions
- Decrease in wound drainage and wound odor
- Formation of healthy granulation tissue
- Open wound edges
- Intact periwound area

Once the infection is under control, dressing changes are decreased to every two or three days. Changes in the type of dressing may also be required as the status of the wound changes.

DRESSING CHANGES AT HOME

Ideally, dressing changes are done in the wound clinic, but this is not feasible for all patients. Patients may still have to go to work or have transportation issues. In these instances, the clinician may train the patient or a caretaker to change a dressing. The individual doing the dressing changes is instructed in clean technique and to observe for the signs and symptoms of wound deterioration, such as increased pain, increased redness, swelling, odor, or increased drainage. It is a good practice for the clinician to outline the area of cellulitis present with an indelible marker and to instruct the patient to contact the wound care team if the redness extends beyond this line.

Diabetic foot ulcers are cleaned at each dressing change and following debridement using either normal saline or a cleaning solution. Cleansing removes devitalized tissue and may also help to remove biofilms from the wound bed. (Biofilms are polymicrobial communities that contain several species of bacteria and fungi and adhere tightly to the wound bed.)

The following considerations are important when first applying a dressing and for subsequent dressing changes:

- If possible, avoid bandaging over toes, since this may cause a tourniquet effect. When bandaging over toes is necessary, place a layer of gauze over the patient's toes and secure it with a bandage from the metatarsal heads to a suitable point on the foot.
- Keep dressings smooth; avoid creases and dressings that are too bulky, especially on weight-bearing surfaces of the foot.
- Ensure that bandages are not tight at the fifth toe and the fifth metatarsal head; if necessary, trim the bandage back in these areas.
- Do not put strong adhesive tapes on fragile skin.
- Use a dressing that conforms to the contours of the wound bed to prevent dead space in the wound.
- Remember that off-loading footwear needs to accommodate the dressing.
  (Wound International, 2013)

PAIN MANAGEMENT

It is now more clearly understood that many patients with diabetic foot ulcers, even those with neuropathy present, can experience wound pain and pain during dressing changes. Therefore, the clinician utilizes strategies to prevent wound trauma and minimize wound-related pain during dressing changes.

The use of soft silicone dressings and low- or nonadherent dressings are known to reduce pain during dressing changes, along with gentle and careful manipulation of the wound. If the dressing becomes attached to the wound bed and is difficult to remove, the clinician must soak it with normal saline or a wound irrigation solution and wait for several minutes before attempting to remove it. It is also important to keep in mind that that patients who have lost protective pain sensation are at higher risk of wound trauma at dressing changes (Wound International, 2013).

Treating Infection

Infection in diabetic foot ulcers can be caused by Gram-positive bacteria, Gram-negative bacteria, and anaerobic bacteria either on their own or in combination. Frequently, infections in diabetic foot ulcers are polymicrobial, meaning that several different organisms are involved.

Gram-positive bacteria associated with diabetic foot ulcer infections are:

- *Staphylococcus aureus*
- *Streptococcus spp*.
- *Enterococcus spp*.
- Coagulase-negative staphylococci (if this organism is positive in a superficial swab culture, it is frequently a contaminant; however, if it is obtained from a deep tissue culture or from a bone culture, it is considered an accurate finding)

Gram-negative bacteria found in diabetic foot ulcers are:

- *Enterobacteriaceae*
- *Pseudomonas aeruginosa*

Anaerobic organisms cultured from diabetic foot ulcers include:

- *B. fragilis*
- *Peptococcus* and *Peptostreptococcus*

Superficial infections in diabetic foot ulcers are often caused by *S. aureus* or beta-hemolytic streptococci. Deep soft tissue infections and osteomyelitis are usually caused by polymicrobial organisms, which include both aerobic Gram-negative bacilli and anaerobes such as anaerobic streptococci, *Bacteroides fragilis* group, and *Clostridium*. However, it has been found that *Staphyloccocus aureus* is an often-occurring single pathogen in these wounds (Auwaerter, 2017). Methicillin-resistant *Staphylococus aureus* (MRSA) is also a common finding in infected diabetic foot ulcers.

OSTEOMYELITIS

Osteomyelitis (infection of the bone) is a common finding in diabetic foot ulcers, especially in patients with moderately to severely infected diabetic ulcers (Wounds International, 2013).

Osteomyelitis can be hard to diagnose in its early stages. Determining an accurate depth of a diabetic foot ulcer is essential. Ulcers that are large, deep, or in the area of a bony prominence are at considerable risk for underlying osteomyelitis. Other indicators of possible osteomyelitis are bone visible in or protruding from the ulcer ("sausage toe").

A positive **"probe-to-the-bone" test** is a simple clinical test for bone infection. The clinician gently inserts a sterile probe or cotton-tipped applicator into the ulcer. Tapping on bone is recognized by a hard, gritty sensation. This sensation is often detected during the ulcer assessment when the clinician is checking the depth of the wound (Wounds International, 2013). The probe-to-the-bone test can be positive in diabetic foot ulcers that do not exhibit any other signs of infection, and osteomyelitis must be suspected in these cases (Edmonds & Foster, 2014).

X-rays are the first step in confirming a diagnosis of osteomyelitis; however, early in the infection, X-rays may not be that useful since it usually takes about two weeks after the infection starts for plain X-rays to pick up changes consistent with osteomyelitis. Studies show that X-rays have about 55% sensitivity in diagnosing bone infection (Driver et al., 2016).

The Infectious Disease Society of America advises that if initial X-rays do not diagnosis osteomyelitis in the presence of clinical findings that are highly suspicious, the next step to consider is magnetic resonance imaging (MRI) (Wounds International, 2013). A bone scan can also be done, but at this time an **MRI** is considered the most accurate imaging technique available in diagnosing osteomyelitis (Armstrong & Lavery, 2016). The reason MRI is considered the most appropriate diagnostic tool is that it provides high-resolution images not only of the bone, but also of surrounding soft tissues, and it is credited with having a diagnostic sensitivity of over 90% (Driver et al., 2016).

Bone cultures are also important in the diagnosis of osteomyelitis. This entails a suitably trained and licensed practitioner, usually a physician or nurse practitioner, obtaining a sample of bone from the ulcer using a sterile technique. Bone biopsies are also useful in identifying the organisms causing the infection and identifying correct antibiotic treatment.

INTERVENTIONS FOR INFECTION

With the confirmation of deep infection and/or the presence of osteomyelitis, a consult to an infection control specialist is imperative. A crucial intervention at this stage is the identification of causative organisms (if that has not already been done) and the immediate initiation of antibiotic therapy.

Another consideration is the need for surgical debridement to remove all devitalized tissue from the ulcer and the drainage of any abscess that maybe present. Slough and necrotic tissue provide a fertile ground for the growth and multiplication of organisms, and infection cannot be treated effectively until these tissues have been removed.

The combination of antibiotic therapy and serial wound debridement (known as ***conservative treatment***) is frequently successful in resolving infection and allowing the ulcer to heal.

Antibiotic Therapy

Treatment normally begins with intravenous antibiotics, either in the hospital setting, outpatient clinic, or in the patient's home, depending on the stage of the wound and the severity of the infection. Some of the most frequently used antibiotic therapies are listed in the table below.

ANTIBIOTIC THERAPIES FOR INFECTION*	
Infection Type	**Antibiotic(s)**
Streptococcus	Amoxicillin, Clindamycin
Staphylococcus	Flucloxacillin, Clindamycin
Anaerobic	Metronidazole, Clindamycin
Gram-negative	Ciprofloxacin, gentamicin, piperacillin-tazobactam
MRSA	Vancomycin, daptomycin, linezolid
* This list is not all-inclusive.	
Source: Edmonds & Foster, 2014.	

Broad-spectrum antibiotic treatment is started immediately before sensitivity reports are available. Potential limb-threatening and possibly life-endangering signs and symptoms include an infection that has spread throughout the patient's foot, wet gangrene, or the development of a hot, red, swollen foot where pain may or may not be present. In addition to antibiotic therapy, these symptoms indicate surgical evaluation and intervention.

Once the appropriate antibiotic regime has been established from culture results, antibiotic therapy is continued for at least 12 weeks. With severe limb-threatening infections, the patient will be hospitalized initially until symptoms are under control and the wound care team believes it is safe for the patient to continue antibiotic therapy on an outpatient basis or at home with the assistance of a home health nurse.

Debridement

During the course of antibiotic therapy, the diabetic foot ulcer is debrided regularly, usually on a weekly basis; however, the frequency is decided by the wound care provider or surgeon. Following each debridement, the clinician assesses the ulcer and the patient's foot for positive signs that the infection is resolving, such as decreased redness and swelling, healthy granulation tissue in the wound bed, decreased wound drainage, and decreased wound odor. (See also "Debridement" earlier in this course.)

Advanced Wound Treatment Options

When a diabetic foot ulcer fails to heal, the wound care team carefully reevaluates the plan of care to ensure that all impediments to healing have been adequately addressed.

- Has the patient been seen by an infection control specialist?
- Have cultures of wound and bone been done and antibiotic therapy started?
- Has a thorough assessment of the patient's vascular status been completed?
- Has tight glycemic control been achieved?
- Is off-loading being consistently implemented?

If the underlying causes have been addressed and the wound is not responding to standard wound management interventions, then it is time for the wound team to look at advanced treatment options. The goal at this stage is to convert a chronic wound environment into one that supports wound healing. Therapies that are frequently used to achieve this goal are:

- Negative pressure wound therapy
- Hyperbaric oxygen therapy
- Application of growth factors
- Skin substitutes
- Protease inhibitors
- Electrical stimulation

NEGATIVE PRESSURE WOUND THERAPY (NPWT)

In NPWT, a filler dressing (commonly a porous polyurethane foam or gauze) is placed in the wound bed and secured with a cover dressing. A pump is attached to the dressing via a special seal in order to provide negative pressure, with the other end of the tubing connected to a drainage containment device. The negative pressure suction applied to the wound removes excess exudate from the wound bed, decreases edema, and decreases bioburden, all of which help to increase perfusion to the wound bed. NPWT also promotes mechanical stretch of the cells in the wound, which assists with granulation tissue formation (Bryant & Nix, 2016; WOCN, 2016).

Studies have shown a significantly improved healing rate in diabetic foot ulcers among patients receiving negative pressure wound therapy (Bryant & Nix, 2016). Before applying NPWT, the clinician must ensure that the wound has been thoroughly debrided, that the wound is free from necrotic tissue and slough, and that the patient is on the appropriate antibiotic therapy to treat infection. Dressings are usually changed three times a week in the clinic by a clinician skilled in the use of NPWT.

HYPERBARIC OXYGEN THERAPY (HBOT)

HBOT has proven to reduce the number of amputations in people with diabetic foot ulcers. However, it is an expensive therapy and usually requires the patient to commit to treatments 3 to 5 days a week for 6 weeks or more.

The patient is placed in a special chamber where 100% oxygen is administered under pressure. The main effect of HBOT is to increase the ability of the blood to supply oxygen to compromised tissues and thus increase wound healing. It is thought that HBOT also assists in the resolution of osteomyelitis by enhancing the oxygen supply to the bone, which increases leukocyte activity.

The Undersea and Hyperbaric Medical Society recommends that patients with Wagner grade 3 or higher diabetic foot ulcers that are not showing improvement after 30 days of standard care are candidates for HBOT to decrease the risk of incomplete healing and amputation. For patients who have surgical debridement of a diabetic foot ulcer or a partial amputation of the affected foot, the recommendation is to add acute postoperative HBOT to the care regime to reduce the risk of a further major amputation and incomplete wound healing (UHS, 2015).

GROWTH FACTORS

Platelet-derived growth factors and human epidermal growth factor have been shown to increase healing in diabetic foot ulcers (Edmonds & Foster, 2014). Studies demonstrate that chronic wounds such as diabetic foot ulcers have low levels of endogenous growth factors, which are essential for wound healing. Providing an external source of growth factors is believed to promote wound repair (WOCN, 2016). Becaplermin gel is the only growth factor currently available. It has been approved by the FDA, for treatment of nonhealing diabetic foot ulcers that are free from necrotic tissue and slough and are appropriately off-loaded.

If the wound does not show indications of healing after two weeks of growth factor therapy or if the size of the wound has not been reduced by 30% in 10 weeks of treatment, growth factor therapy is discontinued. Becaplermin gel carries a “Black Box” warning for the increased risk of cancer with the use of three tubes or more (Netsch, 2016).

SKIN SUBSTITUTES

Significant healing of diabetic foot ulcers has been obtained with the use of bioengineered skin substitutes (Edmonds & Foster, 2014). Skin substitutes deliver growth factors to the wound bed, which in turn stimulates wound healing. The ulcer should be free of necrotic tissue and slough and have an adequate vascular supply. There should be no exposed tendon, bone, or muscle in the wound bed (Bryant & Nix, 2016). There are several bioengineered skin products on the market, and the clinician must follow the manufacturer’s instructions on the correct method of application. Usually, dressings are changed once a week with a complete assessment of the wound.

PROTEASE INHIBITORS

Collagen is the most common protein found in the body, and it is a vital constituent of wound healing. However, chronic wounds such as diabetic foot ulcers that fail to heal contain high levels of proteases called MMPs, which are enzymes that destroy collagen.

Collagen dressings help to decrease the level of protease in the wound by forming a chemical bond with MMPs.

Collagen dressings come in several different formulations and are typically made from bovine, avian, or porcine collagen. They are nonadhesive, nonocclusive dressings that are applied directly to the wound bed and a secondary cover dressing. Dressing frequency depends on the product used, the amount of wound drainage, and the frequency of wound assessment (Bryant & Nix, 2016).

ELECTRICAL STIMULATION

Electrical stimulation utilizes the transfer of electrical current to the wound to assist with wound healing. Studies indicate that this therapy can produce significant wound healing. It is proposed that electrical stimulation works by increasing protein synthesis in the wound, increasing cell migration, and decreasing bacterial growth (Armstrong & Lavery, 2016).

Electrical stimulation is applied by a physical therapist or occupational therapist who has training and experience in the use of this therapy. Direct current electrical stimulation is the form used in wound care. It is a constant, one-way current in which the voltage does not change with time. It should not be used in the presence of osteomyelitis and with patients who have electric implants such as pacemakers (Bryant & Nix, 2016).

SHOCKWAVE TREATMENT

A recent development in the Unites States is the FDA approval of the first shockwave device for the treatment of diabetic foot ulcers. It is recommended for use with diabetic patients who are 22 years and older and who have a chronic diabetic foot ulcer (greater than 30 days). The new technology utilizes energy pulses to activate wound healing (Gustaitis, 2018).

OFF-LOADING

Off-loading is the most frequently used treatment for diabetic foot ulcers, especially for plantar ulcers. It physically alleviates pressure from the wound and surrounding tissues and allows for redistribution of pressure across a greater area of the foot. Off-loading also eliminates shear, protects the bony structure of the foot, and facilitates increased circulation to the wound (WOCN, 2016).

The International Working Group on Diabetic Foot Ulcers has made the following recommendations on the role of off-loading in the treatment of uncomplicated diabetic foot ulcers:

- Pressure relief needs to be a part of the treatment plan for all diabetic foot ulcers.
- TCC and nonremovable walker casts are the preferred forms of off-loading.

- Normal footwear and standard therapeutic shoes should not be used in an attempt to provide off-loading.
- Patients should be advised to limit standing and walking and to rest with the affected extremity elevated as much as possible.
  (International Best Practice, 2013)

Total Contact Casting

Total contact casting (TCC) is regarded as the gold standard for healing diabetic plantar ulcers, with reported healing rates of between 72% and 100% over a period of 5 to 7 weeks. These healing rates are achieved by consistently distributing pressure over the complete plantar surface of the foot and by ensuring patient compliance since the cast cannot be removed (Armstrong & Lavery, 2016). However not all patients are candidates for total contact casting. The most important consideration is adequate circulation to the extremity.

TCC APPLICATION

A total contact cast has minimal padding and is gently molded to the shape of the patient's foot. A rocker bottom walking plate or sole is attached to assist with walking while at the same time eliminating pressure during ambulation (Varnado, 2016).

INSTRUCTIONS FOR TOTAL CONTACT CASTING

- Explain the procedure to the patient.
- For most patients with diabetes, have them sit on the treatment table with their legs hanging down. Alternatively, have the patient lie on their stomach with the affected leg pointing up; however, many patients, especially older patients, will not find this a comfortable position.
- If a diabetic ulcer is already present, cover the ulcer with a dressing that can be left in place for several days before the cast is applied.
- Keep the patient's ankle in a neutral position while the cast is being applied.
- Prior to discharge, instruct the patient on safe ambulation when wearing a cast. Normally, patients will need to use a walking cane, crutches, or a wheelchair for safety while the cast is in place. Instruct patients who are ambulating with a cast to immediately report the onset of hip or back pain to their healthcare provider, as this may indicate musculoskeletal strain due to the cast.
- Instruct the patient to keep the casting material dry. A shower bag (available at most pharmacies) can be used for this purpose. Alternatively, instruct the patient to wrap the cast in plastic and secure it with tape while showering. Some patients will find it easier to use a shower chair and keep the leg with casting outside the shower curtain.

DISADVANTAGES TO TCC

There are drawbacks to using TCC as an intervention for an existing diabetic foot ulcer. One of the most critical is that it prevents frequent wound assessment since the cast is normally only replaced once a week. However, a skilled clinician can apply a TCC with cut-out windows around the wound(s), which allows for dressing changes and wound inspection in the interval between TCC changes (Bryant & Nix, 2016).

Other disadvantages of TCC include:

- It must be applied by fully trained and experienced clinicians.
- It is time consuming to apply and remove.
- Improper application can lead to skin irritation and further ulcer development.
- In most cases it makes it impossible for the patient to continue working.
- It can make it difficult for the patient to sleep.
- The cast must be kept dry, so showering and bathing becomes a problem.
- It can be uncomfortable to wear, especially during warm and hot weather.

INSTANT TOTAL CONTACT CAST

The Instant Total Contact Cast (iTCC) is an innovative approach that combines the concept of a removable cast walker (see below) and TCC. The patient is fitted with a removable cast walker, which is then wrapped with a layer of cohesive bandage, or casting tape, converting it into an unremovable device, or at the very minimum a difficult-to-remove device. Studies show favorable outcomes with iTCC, and one study found no difference in healing times between TCC and iTCC. The advantages of iTCC include easier access to the wound and surrounding tissues, easier application than TCC, less time to apply, and greater cost-effectiveness (Armstrong & Lavery, 2016).

The clinician needs to take extra care to ensure that the cast walker is the correct fit for the size and shape of the patient's foot and will not cause further areas of pressure, which is an important consideration in patients who have lost protective sensation and are unable to detect pain or discomfort (WOCN, 2016).

Removable Cast Walkers

Other options for off-loading diabetic foot ulcers are removable devices, although none of them has demonstrated the same healing rates as TCC. However, such devices do allow for frequent wound inspection and are often a better match for the patient's lifestyle. They permit patients to bathe and sleep more comfortably.

The biggest drawback with removable devices is a common lack of patient compliance, and this may account for their decreased effectiveness compared to TCC. The findings from one study indicated that patients wore their removable offloading device less than 30% of the time on a daily basis (International Best Practice, 2013).

Another alternative to TCC is a prefabricated pneumatic walking brace (PPWB) fitted with a custom insole (Edmonds & Foster, 2014). PPWBs have the advantage that they are easy to remove, have a high satisfaction rating with patients, and have not been associated with any major complications. They are made from a lightweight, partially rigid casing with an inner lining that supports the patient's lower leg on the affected side to a few inches below the knee. They are usually secured in place with buckles and Velcro straps. However, they have limited use in patients with severe foot deformity. A further drawback is patient compliance, since this is a device that can be removed at home (Galhoum & Abd-Ella, 2016).

Since most patients do not consistently wear removable cast walkers, patient education on this topic is vital. Walking even short distances without a cast walker is contraindicated and puts the patient at risk for a nonhealing ulcer and possible amputation (Armstrong & Lavery, 2016).

Felt Foam Dressing

Felt foam dressing (FFD) is sometimes referred to as the "poor person's TCC" because it is constructed of inexpensive gauze dressings and foam. It provides the off-loading advantages of TCC and is used along with special footwear such as a surgical shoe or a walking splint. The FFD is constructed using adhesive felt cut to accommodate the shape of the patient's foot, with a window cut out over the wound site.

The clinician applies skin-prep to the patient's foot then places the adhesive side of the felt to the patient's skin, ensuring that the window is directly over the wound site. The pad is then wrapped in place with a gauze bandage, secured with tape, and covered with a sock or stockinette. Finally, a surgical shoe is applied (WOCN, 2016). The clinician must ensure that the edges of the felt foam are beveled before applying it to the patient's foot. This prevents incorrect distribution of pressure known as *edge effect* (Bryant & Nix, 2013).

How often FFD is changed is often dependent on the patient's ability to return to the clinic. Notably, one study indicated that felted foam reduces peak plantar pressure at the wound site by approximately 70% for the first three days of wear but by the fourth day has lost the ability to provide pressure relief (Armstrong & Lavery, 2016).

Healing Shoes

Inexpensive, off-the-shelf shoes are available that provide off-loading and enhance wound healing. These shoes also have the advantage of being reusable. Darco boots are one example of this type of footwear; they provide room for bulky wound dressings and closed-toe protection. They can also be fitted with cushioning insoles (Edmonds & Foster, 2014).

Off-loading shoes. (Source: Darco International, used with permission.)

An important feature of **pressure-relieving shoes** is a specialized insole that allows for customized pressure relief using a removable peg system. The first step is for the clinician to place a transparent film over the wound and outline the wound site with a marker. The clinician then asks the patient to step on the insole, which transfers the shape and area of the wound onto the insole. The clinician then removes the pegs from the insole in the area of the wound, effectively off-loading the wound site when the patient ambulates.

Other variations of these shoes include the Ortho-wedge forefront off-loading shoe and the heel wedge off-loading shoe (Varnado, 2016). The Ortho-wedge forefront off-loading shoe provides pressure relief for the toes and metatarsal head using what is known as a *rocker bottom wedge.* The construction of this shoe, which includes 10 degrees of built-in dorsiflexion, redistributes weight from the forefoot to the hind-foot, while the presence of a semi-rigid heel adds stability. The heel wedge off-loading shoe removes pressure from the posterior end of the patient's foot, with pressure being transferred to the mid-foot and forefoot areas (Edmonds & Foster, 2014).

Healing shoes have the same disadvantages as other removable pressure-relief devices, particularly patient compliance. Another concern is safe ambulation, and the wound care clinician (nurse, physical therapist, or occupational therapist) must ensure that the patient receives instruction on walking safely when wearing healing shoes. The clinician should also caution the patient that driving while wearing healing shoes is not advisable; family members and friends should be enlisted to assist with transportation.

Other Off-Loading Devices

Crutches, knee scooters, walkers, and wheelchairs can also be used to assist with off-loading.

Safe ambulation and stability are crucial for a patients using these off-loading devices. The physical therapist determines the most appropriate mobility aid for the patient based on the patient's current mobility status, i.e., wheelchair, walker, or crutches.

Physical therapy interventions also include exercises for balance and coordination and gait training. Therapists instruct the patient on the type of gait that will allow for safe ambulation, usually 3-point gait for patients with off-loading. Other team members also observe that the patient is performing the gait correctly and reinforce teaching.

It may also be necessary for an occupational therapist to do an assessment of the patient's home environment, with the patient's permission, to determine what hazards and risks are present for safe mobility. For example, for a patient on crutches who has stairs at home, negotiating stairs with crutches must be included in the patient education (Inverarity, 2018).

CRUTCH WALKING

Crutch walking is a special technique and requires instruction from a physical therapist, who also ensures that the crutches are a correct fit for the patient. Therapists recommend either axillary or forearm crutches depending on the patient's overall condition and level of trunk stability. The therapists also ensure correct sizing and positioning of the crutches. It is recommended that crutches reach to 1 to 1-1/2 inches below the patient's armpits when standing erect. Younger patients do better with crutches than older patients, who may not have the upper body strength and endurance to safely use crutches. Crutches should not be prescribed for a patient with postural hypotension.

There are several different gait patterns that can be used with crutches. For individuals who are non-weight-bearing on one leg, the recommended gait pattern is 3-point crutch gait. The physical therapist instructs the patient in the following step sequence:

- Move both crutches and the non-weight-bearing leg forward in one movement.
- Bear weight down on the crutches and move the unaffected leg forward.
- Repeat this pattern of movement.

While this gait pattern eliminates weight from the affected leg, it also requires that the patient has good balance to be able to perform it safely (Inverarity, 2017).

KNEE SCOOTER USE

Knee scooters provide a good alternative to crutches for many patients. With the patient placing their body weight on the knee-pad, the unaffected leg is in contact with the ground and provides for propulsion. The clinician will adjust the height of the knee rest so that the patient's knee is at 90 degrees. Although scooters are safer to use for patients than crutches, they do have limitations. Scooters cannot be used on stairs, and they can be more bulky and difficult to load into a vehicle compared to crutches.

Knee scooters come in a two-, three-, or four-wheeled version. Smaller units are suitable for indoor use only, while the larger, stronger versions can be used outdoors. Before recommending a knee scooter for a patient, the clinician will need to ensure that the patient does not exceed the weight limitations for the scooter.

Safety instructions provided prior to using a knee scooter are:

- Do not use the scooter to pull up from a sitting position.
- Before getting on the scooter, make sure the brakes are locked.
- Wear comfortable, nonskid footwear on the nonaffected extremity.
- Use extra caution when changing from one surface gradient to another (i.e., from the sidewalk to the street).
- Use extra care and slow down when going around corners.
- When moving from the scooter to a chair or other surface, back the scooter up to the seat and lock the brakes.
  (IHH, 2014)

The clinician will also look at payment sources for renting or purchasing a scooter: Is it covered by the patient's insurance, or will the patient have to pay part or all of the cost out of pocket?

WALKER USE

Many patients may find that a walker provides more stability and comfort than either crutches or a knee scooter. There are several types of walkers, including standard, two-wheeled, three-wheeeled, or four-wheeled (rollator). The clinician will select the type of walker most appropriate for the individual patient's abilities and needs. A physical therapist may need to work with the patient to ensure safe gait technique when using a walker.

The following instructions provide a general guideline for safe use of a standard walker:

- Begin by standing in the center of the walker.
- Clasp the walker grips with both hands.
- Move the walker forward to a distance that feels comfortable.
- Do not over-reach; the back legs of the walker should be even with the patient's toes.
- Step forward into the center of the walker with the affected leg.
- Step forward with the nonaffected leg; while doing this step, place some weight on the arms.
- Maintain a firm hold on the walker with both hands.
- Do not attempt to move until all four legs of the walker are securely on the walking surface.
- Do not use the walker to pull up from a sitting position.
- Maintain good posture while walking; avoid leaning over the walker.

- Take extra care and time when using a walker on a carpeted surface or when using an elevator.
- Never use a walker on stairs or an escalator.
  (UPMC, 2018)

WHEELCHAIR USE

Wheelchairs provide for total off-loading. Safe technique is important when training a patient to use a wheelchair and is individualized to a patient's needs and abilities. A few general safety recommendations include the following:

- Ensure that the wheelchair is locked before getting in or out of it.
- Do not place heavy items on the back of the wheelchair; this could cause the wheelchair to topple over.
- Adjust the arm- and footrests to maintain good posture and comfort.
- When getting in or out of the wheelchair, first move the footrests to one side to prevent tripping over them.
  (KD Healthcare, 2017)

Assessing Off-Loading Effectiveness

Regardless of the choice of off-loading, it is essential for the clinician to continually assess its effectiveness in providing pressure relief to the area of the ulcer. Indicators of effective off-loading include:

- Progress in wound healing, demonstrated by the presence of healthy granulation tissue and a decrease in wound dimensions
- No or very little reoccurrence of callus formation around the wound
- Absence or resolution of local inflammation (decreased redness, swelling, and skin temperature)

The clinician also monitors the nonaffected extremity closely, since mechanisms used for off-loading can often cause undue pressure to the unaffected limb, increasing the risk for new ulceration (Armstrong et al., 2014).

AMPUTATION

Diabetic foot ulcers are the most frequent cause of amputations. Statistics show that 85% of amputations occur after the development of a diabetic foot ulcer that fails to heal (Scheffler, 2012).

Amputations are most commonly performed to prevent spread of infection and to salvage the remaining unaffected part of the limb. The types of amputations performed include amputation of metatarsal heads, Ray resection (when the complete toe is removed), mid-foot amputation, hind-foot amputation, or below-the-knee amputation.

A primary goal is to carry out the lowest level of amputation possible so that the patient can remain ambulatory, with or without a prosthesis, and avoid the need for more surgery in the future. If possible, the surgeon will opt for a partial foot amputation such as Ray amputations, transmetatarsal amputations, and Syme's amputation (removal of the affected foot at ankle level) (Varnado, 2016).

Determining Amputation Type

When deciding on the level of amputation, the surgeon and the wound care team take into careful consideration the circulation status of the extremity. It is essential that there is adequate circulation to the area of amputation to ensure healing post surgery. Ray amputation is required when tissue death has spread within the base of the toes but with limited spread to the patient's forefoot. A Ray amputation will remove the effected toe or toes along with a portion or all of the corresponding metatarsal. Ray amputations usually preserve more function than transmetatarsal (TMT) amputations, but forefoot stability is decreased when more than two Rays are removed (Edmonds & Foster, 2014).

When extensive infection and necrosis has spread to the forefoot, a transmetatarsal amputation will be required. This surgery will leave the patient with a residual limb that can bear weight after wound healing is complete (Edmonds & Foster 2014).

When infection spreads beyond the patient's foot and there is inadequate perfusion, a below-knee amputation is typically performed. If feasible, the length of the patient's leg remaining below the knee will be in the range of 5 to 7 inches to accommodate prosthetic leg fitting once the surgical wound has healed (AOFAS, 2018).

AMPUTATION INCIDENCE AND MORTALITY

The incidence of amputation of the contralateral limb within 2 to 3 years of the first amputation is between 50% and 84%. However, the intervention of a multidisciplinary footcare team can reduce the incidence of contralateral limb amputation to as low as 7% and help to reduce overall lower extremity amputation rates due to diabetic foot ulcers (Bryant & Nix, 2016).

Studies also show that the 5-year mortality rate for diabetic patients after undergoing a major amputation is higher than many types of serious cancers (Armstrong & Lavery, 2016). Available figures indicate that the mortality rate three years post surgery for a diabetic patient with a lower extremity amputation is between 20% and 50%. For diabetic patients who undergo an above-knee or below-knee amputation, the 5-year survival rate can be as low as 28% (Bryant & Nix, 2016). These figures demonstrate the importance of clinicians working aggressively to prevent wounds reaching the stage where amputation is necessary. However, even with the best care in the world, this is sometimes an unavoidable outcome for many patients.

Pre-Operative Care

Pre-operative care unique to amputation surgery falls into two main areas: ensuring the patient is in the best physical shape possible for surgery and preparing the patient emotionally for the surgery.

Cardiorespiratory status is assessed in close consultation with the patient's primary care physician and cardiologist, if applicable. Tight glycemic control, along with smoking cessation if the patient is a smoker, will optimize wound healing post surgery. Studies have shown a direct correlation between glycemic control and surgical outcomes. Elevated hemoglobin A1C levels are associated with serious postoperative complications, more frequent ICU admissions, and longer hospital stays (ADA, 2018b).

Patients undergoing an amputation, regardless of the level, are going to be fearful and often shocked and angry that a foot wound could lead to losing part of a limb. The clinician needs to be supportive, listen, and realize that the patient's anger is not directed at them personally. The patient and their family will also be apprehensive about what to expect post surgery and how the amputation will affect their lives. The follow-up plan for post surgery should be discussed in detail with the patient and family and their concerns addressed.

If possible, the patient and family should visit the rehabilitation unit prior to surgery in order to meet with the staff and tour the facility. This helps to alleviate the fear of the unknown.

Regarding the financial burden, the case manager or social worker on the team will act as a liaison between the patient and their medical insurance provider, ensuring that coverage is available for rehabilitation, prosthesis, and adaptive equipment. The patient and family are educated about out-of-pocket expenses and options about how these might be covered.

Postoperative Care

In the immediate postoperative period, **monitoring the amputation site** for hemorrhaging is critical. Changes in vital signs, such as an increase in pulse rate or decrease in blood pressure, can be indicators of hemorrhaging under the residual limb dressing, along with increase in blood staining on the dressing. These signs should be reported to the surgeon and closely monitored.

Some surgeons prefer to remove the first **postsurgical dressing** themselves or at least to be present when it is removed so that they can inspect the wound. The incision line is gently cleaned with normal saline and examined for approximation of the skin edges, amount of drainage, and residual limb (sometimes referred to as *stump*) swelling. Dressing type will depend on the surgeon's preference or recommendation from wound care team and usually includes a noncontact layer over the incision line, absorbent gauze dressings, and stretch bandages to assist with residual limb shaping.

Residual limb positioning postsurgery requires special attention to prevent the development of contractures. Patient education focuses on the importance of correct positioning and requires the expertise of physical therapy to provide the most comfortable positioning for the patient. Frequently, the residual limb is elevated on pillows, and the patient may complain that this position is uncomfortable. For below-knee amputations, it is advisable to position the knee in extension to avoid contractures; elevating while sitting can help. For above-knee amputations, it is advisable to position the hip in neutral or slight extension to avoid contractures; prone lying is a good option to allowing optimal hip range of motion. Caution is advised when sitting upright to avoid prolonged flexion.

Pain management is an important consideration in the postamputation patient. Studies show that up to 70% of postamputation patients experience pain described as aching, cramping, burning, throbbing, or shooting (INS, 2016). Pain experienced after an amputation can be divided into phantom limb pain (see box below) and residual limb pain. Research shows that many patients have difficulty distinguishing one type of pain from the other (Hsu & Cohen, 2013).

Residual limb pain is concentrated in the remaining part of the extremity. It can be either superficial and limited to the incisional site, or it can be penetrating pain deep into the tissues of the residual limb. Residual limb pain begins in the immediate postsurgical period and usually disappears with healing; it can also become chronic and persist for years.

Opioids, both oral and intravenous administration, can be used in the immediate postoperative period to treat pain. When using opioids, the prevention of constipation must be considered and may require the provider to prescribe a stool softener or laxative for the patient (Drugs.com, 2018). Other pharmacologic treatments include calcium channel blockers, anticonvulsants, and antidepressants (Hsu & Cohen, 2013). In the postoperative period, clinicians perform frequent pain assessment and ensure that prescribed analgesics are administered. A patient in postoperative pain may not be able to optimally participate in self-care activities, learn new skills, or have an optimistic view of recovery.

Patients with an amputation are at high **risk for falls**, and patient education focuses on the need for safety. Patients are instructed not to attempt to get out of bed without assistance, while family members and caretakers are instructed not to assist the patient with transfers until they have received training from physical therapy (Ruff, 2018).

PHANTOM LIMB PAIN

Phantom limb pain is a frequent and often frightening experience for patients post amputation, in which they experience pain or an unpleasant sensation in the body part that has been amputated. The mechanism that causes phantom limb pain is not clearly understood, but it is believed that factors in both the peripheral and central nervous system play a role. The descriptors that patients use to describe phantom limb pain include a burning, pricking, or shooting sensation. Patients who have phantom limb pain are found to have an increased risk for residual limb pain, which differs from phantom limb pain in that it is felt in the residual limb (Wright, 2015).

Medications used to treat phantom limb pain include tricyclic antidepressants and anticonvulsants; nonpharmacologic treatments include acupuncture and nerve stimulation.

The use of a mirror box is a novel idea for treating phantom limb pain, based on the concept of body perception and brain mapping of integral parts of the body. Updating body perception depends a great deal on tactile information from parts of the body, however after an amputation, this input is lost and the "brain map" is trapped in the perception that existed prior to the amputation. It is thought that phantom pain occurs because patients believe that the limb is held in an awkward, painful position that they cannot rectify.

The basis behind the mirror box is that it appears as if the amputated limb still exists. The mirror box has two openings—one for the intact limb and one for the residual limb. The mirror allows the patient to see a reflection of the intact limb, creating the visual input that both limbs still exist. The patient performs movements and observes the intact limb moving while imagining that the amputated limb is moving. The brain is tricked into believing that the missing limb is being moved into a pain-relieving position. Instructing a patient in the use of mirror box therapy is done by a PT or OT who is familiar with this treatment modality. Research has shown that it is effective in relieving phantom limb pain (Moller, 2014).

Using a mirror, the brain is "tricked" into seeing two limbs. (Source: © Sköld et al., 2011.)

Follow-Up Care

In the following weeks, the clinician continues to monitor for healing and decreased swelling in the residual limb. Edema can often present a problem. Compression "stump" shrinkers and bandaging help to provide good edema control.

During this time, the patient and family will continue to need emotional support. Patients frequently have a difficult time looking at the amputation site and will need encouragement to participate in their own care.

Delayed healing is a problem for patients with diabetes, especially if there is associated peripheral vascular disease and decreased circulation to the amputation site. During follow-up appointments, clinicians monitor the wound closely for signs of delayed healing and infection. Dehiscence (separation of the wound edges) is another major concern post amputation.

There may be a considerable period of rehabilitation when the patient will need interventions from multiple disciplines—including nursing, physical therapy, and occupational therapy—to maintain safety, mobility, and assistance with self-care.

It is important to ensure that the patient will be in the best physical condition possible for a future prosthesis fitting. Limb wrapping and using an elastic shrinker sock are essential to preparation for prosthetic fitting. Physical therapists are specialists in this area of care and will guide other team members in correct residual limb management. The timing for prosthetic fitting depends on how quickly the wound heals. In most instances fitting begins somewhere between eight weeks to six months postsurgery (Amputee Coalition, 2015).

Referral is made to a dietitian if there is a concern about malnutrition or poor appetite.

Prosthetic Care

The length of time from surgery to fitting a patient with a prosthesis depends greatly on the level of amputation and how quickly the wound heals. Most often a prosthetic fitting starts about two to six months postsurgery.

Statistics indicate that 90% of those who have a partial foot amputation will be able to use a prosthesis and maintain their mobility. For those with a below-the-knee amputation, the figure drops to 75%, and only 25% of those with an above-the-knee amputation will be successful with a prosthesis and independent mobility (Varnado, 2016).

A prosthetist is involved early on in the patient's postoperative care and assists in preparing the patient's residual limb for fitting and also educates the patient in care of their new prosthetic device. Physical therapists help the patient learn to walk safely with an artificial limb, develop a training program for the patient, and monitor their progress. Patients are also instructed on how to apply prosthetic socks and liners correctly, to change them daily, and to wash them following manufacturer recommendations.

Clinicians must be aware that the residual limb is at high risk for ulceration, and many times this is preceded by callus formation. All disciplines are therefore involved in careful monitoring of the residual limb to ensure that it is tolerating the new prosthesis and that there are no areas of redness that might indicate undue pressure. If redness does occur, the prosthetist is informed immediately and adjustments made to the prosthetic fit.

Since a major amputation also puts the contralateral extremity at greater risk for ulceration, suitable footwear and education to prevent ulceration must be focused on the remaining foot.

Reintegration into Normal Routine

Getting back to normal life or defining a new normal can often be difficult for a patient after an amputation. The stressors patients face include medical expenses, whether they will be able to return to work, whether they will be permanently disabled, how their family and friends will react, and how they will cope personally with an altered body image.

Losing part of one's body damages body integrity and can have a serious negative impact on a patient's physical and psychological condition. A recent study showed that the loss of a lower limb had a significant effect on patients' body images and that female patients with a lower limb amputation showed considerable difficulty adjusting to a new body image compared to their male counterparts (Holzer et al., 2014). All members of the wound care team are involved in helping the patient cope with changes in body image, with clinicians' acceptance and respect for the patient as "a whole person" providing a positive image. For patients who exhibit severe denial or depression, a consultation to a mental health specialist is advisable.

Physical therapists and occupational therapists can give valuable input on workplace ergonomics and assistive devices needed to maintain employment. Several studies have shown that interventions from these therapists result in:

- Decreased risk of complications post amputation
- More successful reintegration into society
- Better emotional health
- Greater patient acceptance of the amputation
- Greater protection of the residual limb
- Increased well-being in a wheelchair

Other studies have found that patients participating in inpatient rehabilitation had higher levels of mobility one year post amputation compared to patients who did not receive inpatient therapy. Data has also demonstrated a potential role for occupational therapy in community-based self-management programs in which postamputation patients receive education on problem-solving, pain management, and improved quality of life (Dorsey & Bradshaw, 2016).

A case manager or social worker on the wound care team can assist the patient with insurance claims and disability benefits.

CASE *(continued)*

Mr. Hernandez missed several appointments at the wound clinic since his wife was ill and he had to put in extra hours at work. When he does return to the clinic, he looks tired and ill.

On examination, the clinician finds an ulcer on the plantar surface of his left foot. The clinician performs a full wound assessment, noting greenish drainage, a malodor that persists after the wound is cleaned, and redness and swelling in the tissues surrounding the wound. When she inserts a sterile applicator into the wound, she is able to probe down to bone.

The physician takes a deep-tissue biopsy from the wound, orders an immediate X-ray, and starts Mr. Hernandez on a broad-spectrum intravenous antibiotic. He also requests that Mr. Hernandez be scheduled for vascular studies to determine the circulation status to his lower extremities.

Mr. Hernandez becomes confused and angry, stating, "All these tests are not needed! It's just a little wound. My wife is putting iodine on it at home." The clinician explains to Mr. Hernandez that, although on the surface of his foot the wound appears to be small, it goes the whole way down to the bones in his foot and that tests are needed to ensure that there is no bone infection. Mr. Hernandez reluctantly agrees to the X-ray but states he doesn't know whether he can come to the outpatient clinic to have IV antibiotics due to his work schedule. He insists that there is no need for vascular studies.

The wound care team also broaches the subject of off-loading with Mr. Hernandez and explains at length to him why it is so important. He responds that he has to work and has to wear his boots.

It is apparent that Mr. Hernandez is not only confused by what is happening, but he is shocked and afraid. It is hard for him to understand that a little hole in the bottom of his foot could be putting his whole limb at risk. However, the wound care team has in the past built up good rapport with Mr. Hernandez, and maintaining that level of trust is important at this stage.

Since Mr. Hernandez insists on continuing to work, the team considers what options are available for off-loading his foot. Off-loading is vital to healing, but it also has to fit in with Mr. Hernandez's choices about his life. The team decides that a felt foam dressing is the best option. Mr. Hernandez's work boots will accommodate the dressing without causing extra pressure to his foot. He will also be advised that when he is not working, he should rest with his feet elevated.

IV antibiotics are also determined to be essential. Once the tissue culture results are ready, Mr. Hernandez will be switched to the appropriate antibiotic to target his infection. The physician will schedule a consult with an infectious disease (ID) specialist, and the case manager will look into scheduling the patient's IV antibiotics around his work schedule and the ID consult. The team also decides that the best course of action is to revisit the question of

vascular studies and a vascular consult once Mr. Hernandez is established with the IV antibiotic therapy schedule and after he has seen the ID specialist.

CONCLUSION

Treatment of diabetic foot ulcers in particular is both challenging and complex and requires a high level of commitment from both the patient and clinician. The importance of diabetic self-management programs is widely recognized, but there are still areas of the country where access to diabetes care and preventive care is lacking.

Interdisciplinary wound care teams have been proven successful in the prevention and treatment of diabetic foot care problems. Not only do wound care teams achieve better patient outcomes, they are also cost effective due to consolidation of services. The intervention of a wound care team improves patient quality of life and enhances physical and emotional well-being (Byrant & Nix, 2016).

As soon as a patient is diagnosed with diabetes, intervention must begin with a foot assessment and patient education on foot care and wound prevention. Clinicians are aware that DPN and Charcot foot may already be present, and signs and symptoms are thoroughly evaluated. For patients who present with a diabetic foot ulcer, the goals are healing and treating infection, which often require advanced wound care modalities. If an amputation is required, the pre- and postoperative care of the patient must take into consideration both physical and psychological well-being. Prosthetic fitting and rehabilitation care aim to return the patient to active participation in society.

RESOURCES

Amputation and diabetes: how to protect your feet (Mayo Clinic)
https://www.mayoclinic.org/diseases-conditions/diabetes/in-depth/amputation-and-diabetes/art-20048262

Diabetes and pedorthics (Pedorthic Footcare Association)
https://www.pedorthics.org/page/Diabetes_Pedorthics

Diabetic foot overview (American Orthopaedic Foot and Ankle Society)
http://www.aofas.org/footcaremd/conditions/diabetic-foot/Pages/diabetic-foot-overview.aspx

Diabetic foot problems (Cleveland Clinic)
https://my.clevelandclinic.org/health/diseases/16929-diabetic-foot-problems

Foot complications (American Diabetes Association)
http://www.diabetes.org/living-with-diabetes/complications/foot-complications/

IDF Clinical Practice Recommendations on the Diabetic Foot (International Diabetes Federation)
https://www.idf.org/our-activities/care-prevention/diabetic-foot.html?view=download&id=222

National Certification Board for Diabetes Educators (NCBDE)
http://www.ncbde.org

National Diabetes Education Initiative
http://www.ndei.org

What is a diabetic foot ulcer? (American Podiatric Medical Association)
https://www.apma.org/Patients/FootHealth.cfm?ItemNumber=981

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TEST

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1. Results from large cohort studies of persons with diabetic foot ulcers (DFUs) found that:

a. A DFU predisposes the individual to invasive skin cancer.

b. Persons with a DFU have higher rates of hypotension than the general population.

c. Persons with a DFU have a greater risk of cardiovascular disease than the general population.

d. A DFU is a risk factor for suicide among middle-aged male patients.

2. Research on diabetes has shown that African Americans:

a. Are twice as likely to be diagnosed with diabetes as non-Hispanic whites.

b. Are less likely to face a lower extremity amputation compared to non-Hispanic whites.

c. Are diagnosed with type 2 diabetes at a later age compared to other racial minorities.

d. Have fewer complications related to diabetes compared to non-Hispanic whites.

3. Which is an important function of the physical therapist on the diabetic foot care team?

a. Assisting the patient with activities of daily living, such as getting dressed.

b. Assessing the patient only after a diabetic foot ulcer has developed.

c. Identifying early structural changes of the patient's foot.

d. Educating the patient on medication management.

4. Diabetes education is best viewed by the clinician as a process that is:

a. Most effectively completed through a few sessions with a diabetes educator.

b. Potentially unnerving for the newly diagnosed patient.

c. Most effectively provided three to six months after diagnosis.

d. Primarily focused on insulin administration.

5. When providing diabetes education to a patient, the clinician ensures that:

a. Medical terminology is used in place of everyday terms.

b. The term "wound" is always used instead of the less common term "ulcer."

c. Each teaching point is presented only once.

d. Teaching materials are age-appropriate for the patient.

6. Patients with diabetes should be screened for depression because:

a. More than half of patients with diabetes are affected by depression.
b. Patients diagnosed with diabetes are often unaware that they are depressed.
c. A patient's psychological state impacts their ability to perform self-care.
d. Less than 5% of patients globally have diabetes-related stress.

7. Which limb assessment finding can be a sign of neuropathy in a patient with diabetes?

a. Skin surfaces that are scaly and weeping
b. Hair growth on the patient's toes
c. Blotchy discoloration of the extremity
d. Deep cracks in the skin, particularly on the heels

8. Which statement accurately describes normal age-related changes to the foot?

a. Fat on the bottom of the foot becomes thicker.
b. Foot anatomy remains constant over the lifespan.
c. The foot becomes shorter and wider.
d. The arch of the foot becomes flatter.

9. When instructing the patient with diabetes on good foot care, the clinician states:

a. Foot checks should be done weekly.
b. Walking barefoot should never be done in any location.
c. If feet are cold, use a heating pad.
d. Wear tight socks.

10. Which recommendation is made to a patient with diabetes in order to improve circulation?

a. Maintain your feet in a dependent position when sitting.
b. Cross your legs only when they are elevated.
c. Perform simple foot exercises several times daily.
d. Wear tight, knee-high socks.

11. Which is an appropriate characteristic of shoes for a patient with diabetes?

a. Room over the toe area
b. Loose fit around the heel
c. Slip-on instead of laced
d. Tight fit over the ball of the foot

12. Which recommendation does the clinician give to a patient with diabetes about buying new shoes?

a. Try the shoes on without socks to ensure a comfortable fit.
b. Shop in the afternoon rather than the morning.
c. Ensure that the longest toe gently contacts the inside tip of the shoe.
d. Wear new shoes all day long to break them in.

13. Inadequate information provided by proprioceptors in the foot may negatively impact a patient's movement, pressure distribution, and:

a. Circulation.
b. Skin integrity.
c. Postural coordination.
d. Activity level.

14. Patchy removal of callus build-up can lead to which complication?

a. Inflammation of nerve endings near the surface of the foot
b. Creation of a portal of entry for infection to the foot
c. Bleeding into the callus and deeper tissues
d. Focal points of excessively high pressure

15. The A1C test measures the patient's:

a. Fasting blood sugar levels.
b. Red blood cell count.
c. Blood sugar levels after eating.
d. Average blood glucose levels over the previous three months.

16. To achieve maximum success with a weight-loss plan, it is important that the dietitian:

a. Take into consideration the patient's food preferences.
b. Encourage the patient to lose at least 15 pounds to make a real difference.
c. Help the patient let go of the wish to find pleasure in food.
d. Avoid discussing the patient's past attempts at dieting.

17. Which is a **correct** statement about peripheral neuropathy?

a. It is a condition characterized by damage to the central nervous system.
b. It is one of the most frequent complications of diabetes.
c. Most patients with peripheral neuropathy are aware that they have the condition.
d. Patients with prediabetes do not develop the condition.

18. Which action by the clinician is **not** part of Semmes-Weinstein monofilament test for sensation on a patient's foot?

a. Ask the patient to close their eyes while the test is being done.
b. Gently slide the monofilament across the patient's foot.
c. Press the monofilament into a "C" shape against the patient's foot.
d. Apply the monofilament three times to each test site.

19. Sensory neuropathy frequently begins with:

a. Itching sensation in the ankle area.
b. Burning or tingling in the toes and feet.
c. Decreased reaction to painful stimuli.
d. Pain with ambulation.

20. When examining the foot of the patient with motor neuropathy, the clinician usually finds:

a. Increase in muscle bulk of the foot.
b. Excessive pressure on the dorsum of the foot.
c. Flaccidity in the patient's toes and ankles.
d. Prominent metatarsal heads and claw toes.

21. Autonomic neuropathy can lead to:

a. Extremely dry feet and the development of fissures.
b. Extremely cold feet that are difficult to warm.
c. Excessive oil production on the feet and legs.
d. Macerated skin and fungal infections.

22. Diabetic patients who are considered at high risk for Charcot foot are those who:

a. Have a history of syphilis.
b. Have been recently diagnosed with diabetes.
c. Have developed diabetic peripheral neuropathy.
d. Have a weakened bone structure in their feet.

23. An important finding that may indicate a diagnosis of Charcot foot is:

a. Decreased pedal pulses in the affected foot.
b. Decreased white blood cell count.
c. Resolution of redness when the foot is elevated.
d. Increased C-reactive protein level.

24. A drawback of total contact casting in patients with Charcot foot is that:

a. It increases the amount of weight-bearing on the opposite limb.
b. There must be complete non-weight-bearing on the affected leg.
c. The extremity must be immobilized within the casting material.
d. It causes redistribution of pressure over the surface of the foot.

25. The location of a diabetic foot ulcer helps to determine:

a. The age of the ulcer.
b. The cause of the ulcer.
c. The depth of the ulcer.
d. The prognosis for the ulcer.

26. When assessing a diabetic foot ulcer, which finding is considered critical and requiring immediate attention?

a. Necrotic tissue
b. Exposed bone in the wound
c. Stringy slough
d. Pink, viable tissue

27. The most common early presenting sign of a diabetic foot infection is:

a. A sudden spike in the patient's temperature.
b. Cellulitis in the tissues surrounding the wound.
c. Elevated white cell count.
d. C-reactive protein level greater than 100 mmol/L.

28. A grade 4 diabetic foot ulcer on the Wagner System indicates:

a. Wet or dry gangrene is present on part of the foot.
b. There is a history of previously healed ulcer.
c. There is exposure of tendon and bone in the ulcer.
d. Gangrene encompasses the entire foot.

29. An ankle-brachial index (ABI) reading of 1.2 in a diabetic patient is considered to be:

a. Normal and an indication of adequate circulation.
b. An indication of compressible arteries in the feet.
c. Abnormal, indicating less compressible arteries.
d. Abnormal, indicating inadequate circulation to the feet.

30. Wound debridement should be done down to a level where:

a. Viable bleeding tissue is found.
b. The top layer of necrotic tissue is removed.
c. All slough is removed from the wound.
d. A pink wound base is reached.

31. Which is a general rule for dressing selection for a diabetic foot ulcer?

a. For dry necrotic eschar, apply a dressing that will maintain the eschar intact.
b. Choose a dressing that is bulky enough to assist with off-loading.
c. Apply an antimicrobial dressing to a wound with granulation tissue.
d. For ulcers with slough, chose a dressing that will assist with debridement.

32. When bandaging a diabetic foot wound, the clinician:

a. Wraps the bandage over all the toes.
b. Places a bulky bandage on weight-bearing surfaces.
c. Ensures that the bandage is not tight at the fifth metatarsal head.
d. Avoids trimming back the bandage over the fifth toe area.

33. Frequently, infections in diabetic foot ulcers are caused by:

a. A single Gram-positive bacteria.
b. A single Gram-negative bacteria.
c. Anaerobic bacteria.
d. Several different organisms.

34. In the diagnosis of osteomyelitis, bone biopsies are used to:

a. Determine how long the infection has been there.
b. Assess the extent and depth of the infected bone.
c. Determine if the infection has spread into other tissues.
d. Identify the causative organism and correct antibiotic treatment.

35. Advanced wound treatment options are used when:

a. A diabetic wound fails to heal.
b. The patient fails to keep twice-weekly appointments.
c. There is a proliferation of unhealthy granulation tissue.
d. The patient requests more intensive care.

36. It is thought that hyperbaric oxygen therapy assists in the resolution of osteomyelitis by:

a. Decreasing the wound bioburden.

b. Decreasing wound edema.

c. Increasing wound drainage.

d. Increasing leukocyte activity.

37. Before applying a bioengineered skin substitute for wound healing, it is important to ensure that:

a. The wound has decreased in size.

b. The patient will be able to return biweekly for dressing changes.

c. The wound is free from necrotic tissue and slough.

d. Antibiotic ointment has been applied to the wound.

38. Which is the **most** critical drawback of using total contact casting (TCC)?

a. TCC is rarely covered by a patient's healthcare insurance.

b. TCC can only be applied in an inpatient setting.

c. Patients can develop severe allergic reactions to some of the components in TCC.

d. TCC prevents frequent wound assessment since it is normally only replaced once a week.

39. The primary purpose of the peg system incorporated into some pressure-relieving shoes is to allow for:

a. Easy dressing changes.

b. Frequent wound inspections.

c. Customized pressure relief.

d. Safe patient ambulation.

40. Which statement **best** describes a Ray amputation?

a. It is required when tissue death has spread beyond the patient's forefoot.

b. It removes the affected toe or toes along with part or all of the corresponding metatarsal.

c. Forefoot stability is maintained when more than two Rays are removed.

d. Ray amputations have a higher rate of revision surgery than other amputations.

41. Medications used to treat phantom limb pain include:

a. Tricyclic antidepressants and anticonvulsants.
b. NSAIDS and tricyclic antidepressants.
c. Steroids and anticonvulsants.
d. Opioids and anti-inflammatory medications.

42. To regain independence after an amputation, it is recommended that a patient:

a. Learn how to use a wheelchair.
b. Learn to ambulate safely with a prosthesis.
c. Increase weight-bearing on the intact leg.
d. Decrease the amount of standing time.