

Review Article

Diabetic foot ulcers: a review of current management

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ABSTRACT

Diabetic foot ulcers are a serious complication of diabetes mellitus which increases the patient morbidity and also have significant socioeconomic impact. The present review aims to summarize the causes and pathogenesis leading to diabetic foot ulcers, various classification systems and to focus on the current management of this significant and preventable health condition.

Keywords: Classification, Debridement, Diabetic foot management, Diabetic foot ulcers, Offloading

INTRODUCTION

Diabetes is a serious chronic disease that requires special attention and is also described as “Global Epidemic”. About 415 million people have diabetes globally which accounts to 1 in 11 people. India has world’s second largest diabetic population with approximately 69 million people with diabetes.

Approximately 15% of all people with diabetes will be affected by a foot ulcer during their lifetime.¹ There is increased incidence of Type-2 Diabetes Mellitus (DM 2) in the past several decades owing to the advancing age of the population, substantially increased prevalence of obesity and decreased physical activity, all of which have been attributed to a western life style.² Occurrence of diabetes at an early age and longer life of diabetic patients have increased the risk of development of the duration dependent complications.³

These complications are not only dependent on duration but also on the level of chronic glycemia, which is best measured by glycosylated hemoglobin assay (HbA1c

Level).³⁻⁵ Foot problems remain very common in people with diabetes throughout the world, affecting up to 15% of diabetic patients during their lifetime.^{1,6} Diabetic foot ulcers increases morbidity, high expenditure for therapeutic management and precede amputations in about 85% of patients. Frequency of lower limb amputations can be lowered by 49-87% by preventing the development of diabetic foot ulcers.^{7,8}

ETIO-PATHOGENESIS OF DIABETIC FOOT ULCERS

Multiple risk factors are associated with the development of Diabetic foot ulcers as per recent studies.^{9,10} These risk factors are as follows: gender (male), duration of diabetes longer than 10 years, advanced age of patients, high Body Mass Index, and other comorbidities such as retinopathy, diabetic peripheral neuropathy, peripheral vascular disease, glycosylated hemoglobin level (HbA1c), foot deformity, high plantar pressure, infections, and inappropriate foot self-care habits (Table 1).⁹⁻¹¹ Most Diabetic foot ulcers till date has been caused by ischemic, neuropathic or combined neuro-ischemic abnormalities

Only 10% of Diabetic foot ulcers are pure ischemic ulcers and 90% are caused by neuropathy, alone or with ischemia.¹²⁻¹⁴ Peripheral sensorimotor and autonomic neuropathy is the most common pathway for development of foot problems in diabetic patients that leads to high foot pressure, foot deformities, and gait

instability, which increases the risks of developing ulcers. And it has been demonstrated that foot deformities and gait instability increases plantar pressure, which can result in foot ulceration.¹³⁻¹⁶

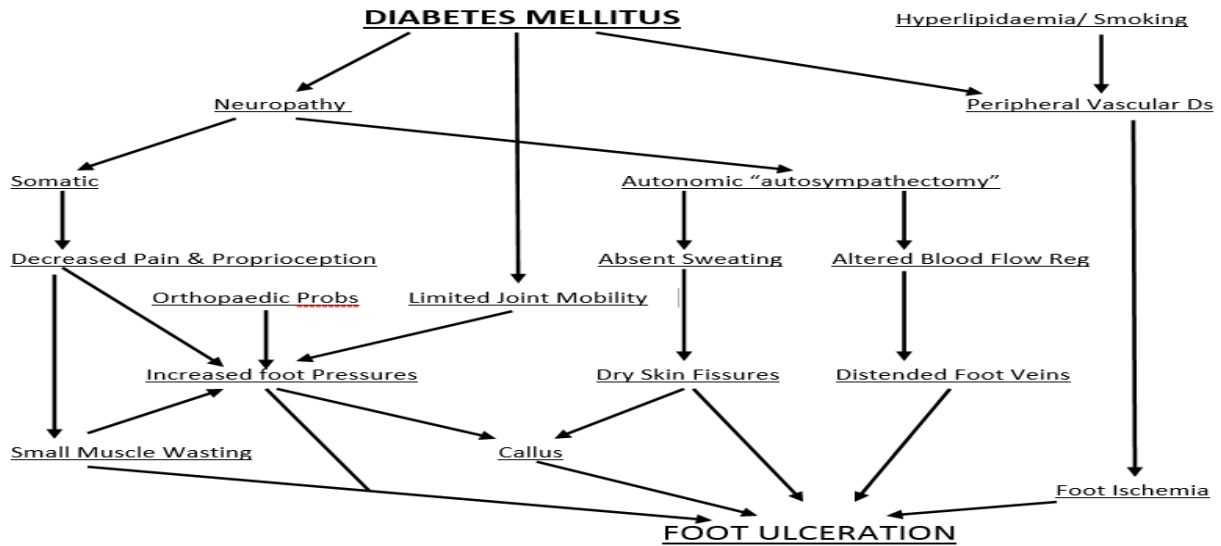


Figure 1: Aetiology of diabetic foot ulcer (data adapted from Boulton et al.¹⁴).

Table 1: The risk factors for diabetic foot ulcer.

General / systemic contributions	Local issues
Uncontrolled hyperglycaemia	Peripheral neuropathy
Duration of diabetes > 10yrs	Structural foot deformity
Peripheral vascular disease	Trauma/ ill fitted shoes
Blindness or visual loss	Callus
Chronic renal disease	History of prior ulcer/ amputation
Older age	Prolonged elevated pressures
High body mass index	Limited joint mobility

DIABETIC FOOT LESIONS CLASSIFICATION

Various classification systems are in use now to evaluate and determine the severity of diabetic foot that attempt to encompass different characteristics of an ulcer (namely site, depth, the presence of neuropathy, infection, and ischemia, etc.) including Wagner System, University of Texas System and a hybrid System, Depth Ischemic classification, the PEDIS System.^{17,18}

Commonly used classification systems are

Wagner-Meggitt Classification

Most commonly and widely used. In this system foot lesions are divided into different grades starting from grade 0 to grade 5. Grade 0 includes high risk foot but no active lesion and grade 5 includes gangrene of entire foot. Only grade 3 addresses the problem of infection. This system does not mention about ischemia or neuropathy and that is the drawback of this system (Table 2).

Table 2: Wagner-Meggitt classification.

Grade	Lesion
0	No open lesion
1	Superficial ulcer
2	Deep ulcer to tendon or joint capsule
3	Deep ulcer with abscess, osteomyelitis, or joint sepsis
4	Local gangrene- fore foot or heel
5	Gangrene of entire foot

Depth-Ischemic classification

It is a modification of Wagner-Meggitt system.

The purpose of this classification system is to make the classification more accurate, rational, easier to distinguish between wound and vascularity of foot, to elucidate the difference among the grades 2 and 3, and to improve the correlation of treatment to the grade (Table 3).

Table 3: Depth-ischemic classification.

Grade	Lesion	
0	No open lesion: may have deformity or cellulitis A ischemic	B infected
1	Superficial ulcer A ischemic	B infected
2	Deep ulcer to tendon or joint capsule A ischemic	B infected
3	Deep ulcer with abscess, osteomyelitis, or joint sepsis A ischemic	B infected
4	Local gangrene- fore foot or heel A ischemic	B infected
5	Gangrene of entire foot A ischemic	B infected

University of Texas classification

University of Texas San Antonio System incorporates lesion depth and ischemia (Table 4). It is actually a modification of Wagner System and is somewhat superior. In this system each grade of Wagner System is further divided into stages according to the presence of infection or ischemia or combination of both.

Table 4. University of Texas classification system.

Stages	Grades			
	0	I	II	III
A	Pre-or post-ulcerative lesions Completely epithelialized	Superficial wound not involving tendon capsule or bone	Wound penetrating to tendon or capsule	Wound penetrating to bone or joint
B	With infection	With infection	With infection	With infection
C	With ischemia	With ischemia	With ischemia	With ischemia
D	With infection and ischemia	With infection and ischemia	With infection and ischemia	With infection and ischemia

Diabetic patients must inspect their feet regularly, or have a family member or care provider do it on their behalf. Daily inspection is important part of diabetic foot ulcer prevention. All wounds, injuries, infections and sores should be taken seriously and early attended. Cleansing regularly and gently with soapy water, followed by the application of topical moisturizers, helps to keep the skin healthy and better able to resist breakdown and injury. Properly fitting shoes with adequate support should be advised (athletic/sports shoes and thick, padded socks) or custom shoes should be considered in the case of foot deformities or special support needs. Minor wounds should be gently cleansed and treated with topical antiseptics. In addition, a physician should inspect any minor wounds that do not heal quickly, and by reinforcing preventive advice and inspecting the patient’s feet at routine follow-ups, the physician can help the

MANAGEMENT OF DIABETIC FOOT ULCERS

The gold standard for diabetic foot ulcer management includes prevention, patient and caregiver education, glycemic control, debridement of the wound, management of any infection, revascularization procedures when indicated, off-loading of the ulcer and reconstructive surgery if needed. Other methods or add-on therapies may be beneficial, such as hyperbaric oxygen therapy, use of advanced wound care products, and negative pressure wound therapy (NPWT/VAC).

PREVENTION/ EDUCATION

About 49-85% of all diabetic foot related problems are preventable. This can be achieved through a combination of good care of foot, provided by an inter-professional diabetes care team, and appropriate education for people with diabetes. Successful diagnosis and treatment of patients with chronic wounds involve holistic care and a team approach. The integration of the work of an inter-professional care team that includes doctors, nurses and allied health professionals with the patient, family and caregivers offers an optimal formula for achieving wound resolution.^{1,19,20}

patient develop and maintain good foot-care practices.^{1,12,13,19,20}

BLOOD SUGAR CONTROL

In patients with diabetic foot ulcers, long-term glycemic control is desirable. The standard of care in diabetes management is self-monitoring of blood glucose and it allows the patient to monitor his or her blood glucose at any time.

Blood glucose monitoring frequency should be individualized and adapted to address the goals of diabetes care. The diabetes management team and patient can improve the treatment program by combining glucose measurements with diet history, medication changes, exercise history and usually involves glucose-lowering medications (Insulin preparations and Noninsulin

therapies). The standard method for assessing long-term glycemic control is measurement of glycosylated hemoglobin (HbA1c). The target for glycemic control (as reflected by the HbA1c) must be individualized, and the goals of therapy should be developed in consultation with the patient after considering many medical, social, and lifestyle issues.

The goal is to achieve an HbA1c as close to normal as possible without significant hypoglycemia. In most individuals, the target HbA1c should be <7%, preprandial capillary plasma glucose 4.4–7.2 mmol/L (80–130 mg/dL) and peak postprandial capillary plasma glucose <10.0 mmol/L (<180 mg/dL).²¹

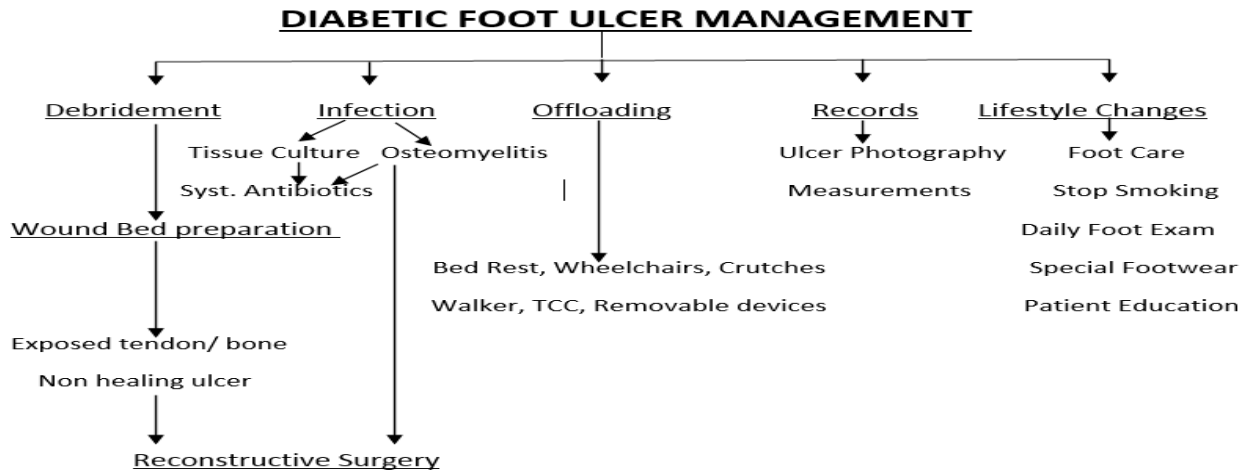


Figure 2: Algorithm for diabetic foot ulcer management.

DEBRIDEMENT/ WOUND BED PREPARATION

Debridement of necrotic tissue is an integral component in the treatment of chronic wounds since they will not heal in the presence of unviable tissue, debris, or critical colonization. Bacterial colonization increases in undermined tissues or closed wound spaces. Debridement of necrotic tissue serves various functions: removal of necrotic tissue and callus; reduction of pressure; evaluation of the wound bed; evaluation of tracking and tunneling; and reduction of bacterial burden. And it also facilitates drainage and stimulates healing.

It improves healing by promoting the production of granulation tissue and can be achieved surgically, enzymatically, biologically, mechanically and through autolysis.²²⁻²⁷

Surgical debridement, known also as the “sharp method,” is performed by scalpels, and is rapid and effective in removing hyperkeratosis and dead tissue. It is one of the gold standards in wound healing management; Care should be taken to protect healthy granulation tissue.²² Enzymatic debridement can be achieved using a variety of enzymatic agents, including crab-derived collagenase, collagen from krill, papain, a combination of streptokinase and streptodornase, and dextrans. It removes necrotic tissue without damaging the healthy tissue. Although expensive, enzymatic debridement is

indicated for ischemic ulcers because surgical debridement is extremely painful in these cases.²³

Biological debridement has been applied recently using sterile maggots. Maggots digest surface debris, bacteria, and necrotic tissues only, leaving healthy tissue intact. Recent reports suggest that this method is also effective in the elimination of drug resistant pathogens, such as MRSA, from wound surfaces.²⁴ Mechanical debridement is a nonselective, physical method of removing necrotic tissue; it may include wet-to-dry dressings and high-pressure irrigation or pulsed lavage and hydrotherapy. Wet-to-dry is one of the most commonly prescribed and overused methods of debridement in acute care setting. Hydrotherapy in the form of whirlpool may remove surface skin, bacteria, wound exudates, and debris.

There may be justification in the early stages of a wound for the use of this technique, but it is detrimental to friable granulation tissue.^{25,27}

Autolytic debridement involves the use of dressings that create a moist wound environment so that host defense mechanisms (neutrophils, macrophages) can clear devitalized tissue using the body’s enzymes. Autolysis is enhanced using proper dressings, such as hydrocolloids, hydrogels, and films. Autolysis is highly selective, avoiding damage to the surrounding skin.^{26,27}

ROLE OF ANTIBIOTICS/ BACTERIAL MANAGEMENT

The high morbidity and mortality associated with infection in Diabetic foot ulcers means that early and aggressive treatment in the presence of even subtle signs

of infection is more appropriate than for wounds of other aetiologies (except for immunocompromised patients)

Note that the optimal duration of antibiotic treatment is not clearly defined and will depend on the severity of infection and response to treatment.

Table 5: General principles of bacterial management.

General principles of bacterial management. (data adapted from) ^{27,28}
At initial presentation of infection, it is important to assess its severity, take appropriate cultures and consider need for surgical procedures
Optimal specimens for culture should be taken after initial cleansing and debridement of necrotic material
Patients with severe infection require empiric broad-spectrum antibiotic therapy, pending culture results. Those with mild (and many with moderate) infection can be treated with a more focused and narrow-spectrum antibiotic
Patients with diabetes have immunological disturbances; therefore, even bacteria regarded as skin commensals can cause severe tissue damage and should be regarded as pathogens when isolated from correctly obtained tissue specimen
Gram-negative bacteria, especially when isolated from an ulcer swab, are often colonising organisms that do not require targeted therapy unless the person is at risk for infection with those organisms
Blood cultures should be sent if fever and systemic toxicity are present
Even with appropriate treatment, the wound should be inspected regularly for early signs of infection or spreading infection
Clinical microbiologists/infectious diseases specialists have a crucial role; laboratory results should be used in combination with the clinical presentation and history to guide antibiotic selection
Timely surgical intervention is crucial for deep abscesses, necrotic tissue and for some bone infections

PRESSURE OFFLOADING

It is important to offload at-risk areas of the foot in patients with peripheral neuropathy, to redistribute pressures evenly. For the healing of plantar ulcers, offloading of the ulcer area is extremely important as tissue damage and ulceration can occur due to inadequate offloading.

The value of ulcer off-loading is increasing, as it has been reported that the risk of recurrence of a healed foot ulcer is high if the foot is not properly offloaded (in the high-pressure areas), even after closure of the ulcer. The gold standard is the non-removable total contact cast (TCC). This is a well molded, minimally padded foot and lower leg cast, made of plaster or fast-setting fiberglass cast material that distributes pressures evenly over the entire plantar surface of the foot. Severe foot ischemia, a deep abscess, osteomyelitis, and poor skin quality are absolute contraindications to the use of a non-removable TCC. Removable devices (such as removable cast walkers, Scotch cast boots, healing sandals and crutches, walkers and wheelchairs) should be used in these patients.^{29,30}

NEGATIVE-PRESSURE WOUND THERAPY (NPWT) / VAC

It involves the use of continuous or intermittent sub-atmospheric pressure through a special pump (vacuum-assisted closure) that is connected to a resilient open-

celled foam surface dressing, covered with an adhesive drape to maintain a closed environment. The pump is then connected to a canister to collect wound discharge and exudates. NPWT optimizes blood flow, decreases tissue edema, and removes exudates, proinflammatory cytokines, and bacteria from the wound area. It should be performed after debridement and continued until the formation of healthy granulation tissue at the surface of the ulcer. Currently, NPWT is indicated for patients with complex diabetic foot wounds; however, it is contraindicated in patients with an active bleeding ulcer.³¹

HYPERBARIC OXYGEN THERAPY

It involves the intermittent administration of 100% oxygen at a pressure greater than that at sea level. It is performed in a chamber with the patient breathing 100% oxygen intermittently while the atmospheric pressure is increased to 2–3 atmospheres for duration of 1–2 hrs. A full course may involve 30–40 sessions. Benefits may be seen in those patients who are ischemic and it may avoid amputations.^{32,33}

OTHER NEWER/ ADVANCE THERAPIES

Newer therapies include use of Bioengineered Skin Substitutes, Growth Factors (PDGF-beta, PRP), Extracellular Matrix Proteins, and Matrix Metalloproteinases Modulators (MMP) which can also

contribute to the overall healing process of the Diabetic foot ulcers wounds in affected patients.

Bioengineered skin substitutes may be a promising therapeutic adjunct therapy to the standard wound care for the management of non-infected diabetic foot ulcers. Some studies have shown encouraging results with new therapies, but certainly, randomized trials are necessary in order to establish their role in the treatment of diabetic ulcers.^{34,35}

RECONSTRUCTIVE SURGERY

Ulcers which have exposed bone, tendons and when the area of the ulcer has not decreased by more than 10% after conservative management for two months should be considered for reconstructive surgery. Surgical options can range from skin grafts to local, regional or free flaps depending on the available donor tissue and the requirements of the defects.

Flaps commonly used for foot ulcers are local transposition flaps, V-Y plantar flaps, medial plantar artery flap, fillet flaps, distally based sural neurocutaneous flaps, and local muscle flaps. Procedures to correct tendon imbalance, particularly Achilles or gastro-soleus tightness correction can decrease foot problems and avoid ulcers. Metatarsal head ulcers in patients with claw toes can be addressed with flexor tenotomies Table 5.³⁶⁻³⁹

CONCLUSION

Patients with diabetes mellitus are at an increased risk for developing foot ulcerations. Patient education and team approach towards management plays the key role towards the success. The diabetic foot ulcers management remains a major therapeutic challenge which implies an urgent need to review strategies and treatments to achieve the goals and reduce the burden of care in a cost-effective and efficient way.

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