The Interdisciplinary Approach

Preventive and Therapeutic Strategies for Diabetic Foot Ulcers

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KEYWORDS

• Interdisciplinary management • Diabetic foot ulceration • Prevention • Therapy
• Diabetes mellitus

KEY POINTS

- Coordinated care between different levels of care is key in the management of diabetic foot ulcer (DFU) patients.
- An interdisciplinary team approach optimises the evaluation and treatment process of DFU patients and has been shown to improve outcomes such as amputation rates, length of hospital stay and mortality rates.
- Early identification and management of risk factors can improve healing and reduce recurrence of DFUs.
- Treatment requires a targeted approach involving an interdisciplinary team of experts of doctors, nurses and allied health professionals.
- Prevention of DFU involves patients and their relatives and strategies should be instituted at all levels of care and continued in the primary care.

PREVALENCE OF DIABETIC FOOT ULCERS AND HEALTH CARE COSTS

The average global prevalence of diabetic foot ulcers (DFUs) is 6.3% with an increasing trend. The lifetime risk of a diabetic developing a DFU is between 19% and 34% based on a study by Armstrong and colleagues.[1] There are also considerable regional differences in the world, with North America having the highest prevalence of DFUs at 13%, Africa at 7.2%, Asia and Europe at 5.5% and 5.1%, respectively, and Oceania with the lowest at 3.0%.[2] Within 5 years of the first occurrence of a DFU, 50% to

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70% of patients in the United States will die and 5% will require a major amputation.[3] Worldwide, it is estimated that DFUs occur every 1.2 seconds, and amputations are performed every 30 seconds.[4] As a result, there is a significant economic burden, with treatment and follow-up costs of DFUs (not including the treatment of diabetes mellitus per se) in North America estimated at $ 9 to 13 billion annually.[5,6]

INTERDISCIPLINARY DIABETIC FOOT CLINIC

Tasks of an Interdisciplinary Team

The main tasks of an interdisciplinary diabetic foot clinic (IDFC) are the treatment of existing DFUs, secondary prevention, prevention of recurrences, and sometimes primary preventions.

The percentage of patients with DFU with peripheral artery disease (PAD) ranges from close to 50% to more than 50% based on current literature.[7,8] Hence, early and appropriate diagnostic evaluation of the extent and localization of the peripheral vascular disease should be done. Early vascular interventions should also be performed if indicated after assessing for contraindications. In noninfected ulcers, which are usually superficial, local surgical debridement, diabetic wound care under a specialist nurse or podiatrist, and appropriate footwear including an off-loading orthosis are prescribed as early as possible. In infected ulcers, which are usually deep, early and aggressive wound debridement is necessary for infection source control and to prevent proximal and systemic progression of infection. For such patients, the IDFC should arrange for hospitalization and start broad-spectrum intravenous antibiotics early. During surgery, numerous deep tissue biopsies allow the team and especially the ID specialist to identify the pathogen, check for bacterial resistance, and to administer the most appropriate antibiotics. The ID specialist's expertise will be crucial when there is the presence of multidrug-resistant bacteria or when patients have contraindications to culture-specific antibiotics. Therefore, the IDFC's access to such expertise should be readily available.[9]

For patients with a high risk of recurrent DFUs, it is key for the endocrinologist to optimize glycemic control and titrate diabetic medications. Next, intensive patient education by a diabetes educator is also vital in reducing the likelihood of recurrence.[10] Further preventive strategies include footwear advice or modification, orthotics, and podiatry care for calluses.

The management of complications of diabetes mellitus such as retinopathy or nephropathy, although not the primary task of the IDFC, should be actively recognized and referred to the respective disciplines for further management.

Optimal Composition of an Interdisciplinary Diabetic Foot Clinic

It has been shown that having an interdisciplinary foot care team along with evidence-based prevention and management reduces the frequency of diabetes-related lower extremity amputation. However, based on a systematic review by Musuuza and colleagues,[3] there is a large variability in the composition of these teams worldwide. The investigators evaluated the optimal composition of an interdisciplinary team and concluded that teams with members who can optimize glycemic control, manage foot wounds, vascular disease, and wound infection are associated with a reduced risk of major amputation, although further studies are still required to clarify the core members.

Graded Team Size

The International Working Group on the Diabetic Foot (IWGDF) guidelines[11] recommend a breakdown into 3 levels of teams (**Table 1**). The first level is a local basic

Table 1
Graded team size according to the International Working Group on the Diabetic Foot guidelines

Level of Care	Specialists Involved
Level 1	General practitioner, podiatrist, diabetic nurse
Level 2	Level 1 and surgeon (foot and ankle, general), endocrinologist, vascular specialist (angiologist und vascular surgeon), infectious dieases specialist, shoe and orthotic technician
Level 3	Level 2 working together in an interdisciplinary way with special expertise in diabetic patients

Data from Schaper et al.[11]

care team, which should be widely available and accessible. A regional team forms the second level, and a tertiary center with a specialized interdisciplinary care setup forms the third level team. The number and expertise of team members involved increases with every level. The first level should be incorporated within the local primary medical care team. The team should consist of podiatrists, wound experts/diabetes nurses, and general practitioners to carry out regular checkups and administer basic routine treatment.[11] Complicated cases or those with a poor outcome should be referred to the next higher level of care. Ultimately, successfully treated cases at centers with level 2 and 3 teams are referred back to the local basic team (level 1) to allow for equitable patient distribution. In a level 2 team, the endocrinologist is probably the most important team member as early treatment and intensive control of diabetes mellitus is one of the major factors in the treatment of DFUs[12,13] and to prevent secondary diabetic complications. Surgical disciplines such as orthopedic, general, and vascular surgeons should ideally be on site. If necessary, interdisciplinary diabetes specialists and podiatrists, as well as shoe technicians and orthotists, should be available. The main difference between a level 2 and level 3 team is that the specialists are on-site at the same time, work together in a coordinated way, and specialize in treating patients with DFU. Ideally, an IDFC and inpatient interdisciplinaryrounds including specialists of level 1 to 3 teams are established in level 3 centers.[14]

Advantages of the Interdisciplinary Team

Interdisciplinary teamwork optimizes efficiency and expedites the evaluation and treatment of patients. In addition, these specialists deal with complex problems on a routine basis with regular communication that helps to accelerate decision-making processes. Clinic-specific algorithms or pathways help to streamline and coordinate the different tasks within the IDFC and help to optimize each patient visit. Furthermore, important diagnostics such as radiographs or vascular workups are carried out in a timely and coordinated manner. The organization of the IDFC depends on the individual hospital's requirements, workflow, and infrastructure. Thus, these processes differ greatly among various clinics worldwide, and there cannot be general recommendations for a consistent organization process.[3,14]

Objectively, with the implementation of an IDFC, 94% of the centers reduced their rate of amputations.[3] Furthermore, length of hospital stay and mortality rates were also reduced with the implementation of IDFCs[15]; this would in turn reduce the

Table 2
Types of ulcer and clinical manifestation

	Neurogenic Ulcer	Venous Ulcer	Arterial Ulcer
Appearance limb	Sensory dysfunction foot deformity	Edema, hyperpigmentation, varicose, eczematous dermatitis	Pale and dry skin, prolonged capillary reperfusion
Location	Pressure exposed region	Malleolar region, tibia	Pressure exposed region, tiptoe
Characteristics	Deep ulcer with reddish base and easy bleeding	Wide range, less necrotic tissue, exudate	Deep ulcer, necrosis, pale ground
Pulse	Mostly normal pulse	Normal pulse and skin temperature	Weak or absent pulse, pale skin
Pain	No relevant pain	Mild or moderate pain that elevated leg	Moderate to strong pain that improves with rest or lowering the leg

Data from Wang et al.[14]

economic burden of the disease. Consequently, various national and international guidelines emphasize the advantages of interdisciplinary teamwork in the treatment of patients with DFU.

DIAGNOSTICS OF DIABETIC FOOT ULCERS

Types of Ulcers

In general, ulcers can be divided into vascular/ischemic, neuropathic, or neuroischemic ulcers that make up the majority. It may be difficult to distinguish vascular from neuropathic ulcers as diabetes mellitus, when long-standing, tends to affect multiple organ systems. Peripheral neuropathy and peripheral arterial disease are also known to be significant independent risk factors for the development of diabetic foot ulcers and their recurrence.[16] **Table 2** shows typical features in terms of clinical appearance and examination results of the various ulcer types.[14]

Classification of Diabetic Foot Ulcers

DFUs can be described using a wide variety of classifications. The early established and most widely used classification is the Wagner or Wagner-Armstrong classification, which, however, is not sufficiently validated.[17] Monteiro-Soares and colleagues recommended that a classification should achieve 3 main clinical aims: to prognosticate, to facilitate communication between health professionals, and to facilitate clinical treatment decision-making. They evaluated 19 different classifications and concluded that currently, no classification sufficiently covers all 3 major purposes to be recommended.[17] The investigators, therefore, suggested using the site, ischemia, neuropathy, bacterial infection, area, and depth (SINBAD) score for communication between specialists and the Infectious Diseases Society of America/IWGDF criteria (**Table 3**) for documentation and infection classification purposes. The Wound-Ischemia-Foot-Infection (WIFI) classification score is useful for assessing vascular perfusion and identifying patients who may benefit from a revascularization intervention.[17]

Table 3
The International Working Group on the Diabetic Foot/Infectious Diseases Society of America classification of diabetic foot ulcer

Clinical Manifestations	Infection Severity	PEDIS Grade P = Perfusion E = Extension D = Depth I = Infection S = Sensation
Would lacking purulence or any manifestations of inflammation	Uninfected	1
Presence of more than or equal to 2 manifestation of inflammation (purulence or erythema, tenderness, warmth or induration), but any cellulitis/erythema extends $\leq$ 2 cm around the ulcer, and infection is limited to the skin or superficial subcutaneous tissues; no other local complications or systemic illness	Mild	2
Infection (as above) in a patient who is systemically well and metabolically stable but that has more than or equal to one of the following characteristics: cellulitis extending > 2 cm; lymphangitic streaking; spread beneath the superficial fascia; deep-tissue abscess; gangrene; and involvement of muscle, tendon, joint, or bone	Moderate	3
Infection in a patient with systemic toxicity or metabolic instability (eg,fever, chills, tachycardia, hypotension, confusion, vomiting, leukocytosis, acidosis, severe hyperglycemia, or azotemia)	Severe	4

Data from Lavery et al.[33]

The SINBAD classification consists of various parameters. One point is allocated for every parameter to a maximum count of 6 points. The classification contains the following parameters:[18]

- S = site, forefoot (0 points), mid- or hindfoot (1point)
- I = ischemia, at least one pulse palpable (0 points), clinical reduced pedal blood flow (1 point)
- N = neuropathy, detecting 10-g monofilament or Neurotip (0 points), no detection (1 point)
- B = bacterial infection, defined by IWGDF criteria if absent (0 points), present (1 point)
- A = area, less than 1 cm^2 (0 points), greater than 1 cm^2 (1 point)
- D = depth, skin or subcutaneous tissue (0 points), reaching muscle, tendon or deeper (1 point)

Identification of At-Risk Groups

The major aims of the IDFC are to identify those patients who are at risk for DFUs and of course to prevent the onset or progression of DFUs. Consequently, patients with an increased risk of DFUs should be thoroughly examined and followed-up closely. In addition, patients and relatives should be educated about the individual risk factors and how to modify these risk factors to reduce complications.[19] The basic clinical assessment is shown in **Table 4**.

Table 4
Basic examination of diabetic patients

History	General history Foot history Foot symptoms
Physical examination	General examination Foot skin and footwear Neurologic examination Vascular examination
Auxiliary examination	Laboratory Ultrasound and electrophysical examination Imaging Pathologic and microbiological examination

ASSESSMENT OF THE MAIN RISK FACTORS FOR DIABETIC FOOT ULCERATION AND RISK CLASSIFICATION

Polyneuropathy

One of the most common risk factors for DFUs is peripheral polyneuropathy.[14] The relative risk of DFUs increases by a factor of 9 to 32 in the presence of polyneuropathy. Up to 78% of patients with diabetes mellitus suffer from polyneuropathy.[20] Typically, polyneuropathy caused by diabetes mellitus is mixed sensorimotor and shows symmetric distribution in both lower extremities. The natural course of polyneuropathy is progressive and irreversible. Clinical symptoms and test-based criteria can be used to diagnose peripheral polyneuropathy. Sensory neuropathy usually begins distally and can present with numbness, paresthesia, hypoesthesia, and dysesthesia and can also present with pain and allodynia. Motor neuropathy may present with muscle atrophy and motor deficits. The wasting of intrinsic foot muscles may result in muscle imbalances and may lead to forefoot deformities such as claw toes.[21] Autonomic neuropathy in the extremities causes sudomotor dysfunction and can present with dry skin, which is more susceptible to injury.[22] The standard examination should include the 10-g Semmes-Weinstein monofilament test, ankle reflexes, blunt/sharp, and warm/cold discrimination. Furthermore, vibration sensitivity should be tested with the 128-Hz tuning fork first at the metatarsophalangeal joint. If there is no sensation, then it should be tested at the medial malleolus.[23] Primary medical care providers can carry out these tests with little effort. If the monofilament and tuning fork are not available, a simpler light touch test can also help detect polyneuropathy.[11] Neurophysiological examinations with nerve-conduction-velocity measurements are still regarded as the gold standard for a sound diagnosis of peripheral polyneuropathy and provided in specialized departments. Muscle-nerve biopsies are usually not necessary in the case of polyneuropathy caused by diabetes mellitus but may be indicated for suspected hereditary neuromuscular disorders. A predominantly motor neuropathy, rapid development, asymmetry, involvement of cranial nerves, or beginning in the arms are atypical for diabetic polyneuropathy. In these cases, other diagnoses should be considered and ruled out by referring them to the relevant specialized departments for further assessment.[24]

Peripheral Arterial Disease

In addition to peripheral polyneuropathy, PAD and foot-intrinsic factors play a decisive role in the development of DFUs. PAD can occur in more than 50% of patients with DFU.[8] In up to 75% of diabetics with PAD, due to polyneuropathy, there are no typical

PAD symptoms such as claudication.[25] In diabetics with PAD, on top of progressive plaque formation in the intima of the arteries, medial artery sclerosis is also well known to be associated with diabetic PAD and is a useful indicator for a diabetic foot at risk.[26] After smoking, diabetes mellitus is the second most important risk factor for PAD. The risk of PAD is 2 to 4 times higher in diabetics than in the normal population. Compared with people without diabetes mellitus, PAD develops earlier in people with diabetes mellitus, progresses faster, and deteriorates more frequently into critical limb ischemia.[8]

The standard vascular diagnostics for diabetics include the following examinations[27,28]:

- Clinical examination with assessment of pedal pulse and capillary refill time
- Ultrasound ankle or toe pressure measurement (ankle brachial index [ABI], toe brachial index)
- Arterial duplex ultrasonography with pulse curve analysis

Other investigations to prognosticate include performing at least one of the following:

- Skin perfusion pressure measurement
- Toe pressure measurement
- Transcutaneous oxygen pressure measurement ($TcPO_2$)

An ABI greater than 0.7 (**Table 5**), a systolic ankle blood pressure greater than 70 mm Hg, and a systolic toe pressure greater than 40 mm Hg are required for appropriate wound healing. If these values are worse—ankle pressure less than 50 mm Hg, ABI less than 0.5, a toe pressure less than 30 mm Hg, or a $TcPO_2$ less than 25 mm Hg[28]—urgent vascular intervention should be considered, particularly, if the debridement- or amputation-wound does not heal.[1,8,28]

Further Intrinsic and Extrinsic Risk Factors

In addition to the 2 main risk factors, peripheral polyneuropathy and PAD, other intrinsic risk factors include altered foot anatomy and biomechanics and psychosocial factors.

The anatomy of the foot is altered due to polyneuropathy, which results in intrinsic muscle atrophy, wasting, and subsequently flexible or rigid claw-und hammertoe deformities. Increased glycosylation in soft tissues such as the Achilles tendon increases

Table 5
Ankle-brachial index

Ankle-Brachial Index (ABI)	Interpretation
0.91–1.30	Normal
0.70–0.90	Mild obstruction
0.40–0.69	Intermediate obstruction
< 0.40	Severe obstruction
> 1.30	Incompressible, sclerotic arteries

Data from Hinchliffe et al.[28]

Table 6
Ulcer and amputation incidence based on The International Working Group on the Diabetic Foot risk classification

IWGDF Risk Classification	Incidence Ulcer (%)	Incidence Amputation (%)
0 Healthy foot	2	0.04
1 Polyneuropathy	3–4.5	0.7
2 Polyneuropathy and pAVKA	13.8	3.7
3 Previous ulcer or amputation	31.7 32.2	2.2 20.7

Data from Lavery et al.[33]

its stiffness and limits ankle dorsiflexion[29–31] and increases stress on the forefoot. There is also increased stiffness in plantar soft tissues, which may also predispose the foot to ulceration.[31] Subsequently, abnormal pressure loads under the metatarsal heads in an insensate foot increase the risk of developing DFUs. Other causes of abnormal loading of the foot such as foot deformities, exostoses, or osteophytes can similarly lead to ulceration. These structural abnormalities may either be caused by diabetic-related cause such as muscle imbalances and Charcot's neuroarthropathy or may be caused by unrelated cause such as posttraumatic arthritis, degenerative arthritis, or congenital deformities. In some cases, the cause may be iatrogenic.[32]

Behavioral and psychological factors such as noncompliance, neglect, and depression are also among the intrinsic risk factors for DFUs.[27]

The extrinsic risk factors include inappropriate footwear, walking barefoot, or prolonged weight-bearing without consistent monitoring of the foot for calluses, blisters, or checking the footwear for foreign bodies. These extrinsic factors have a negative impact on the occurrence and healing of DFUs.[14]

International Working Group on the Diabetic Foot Risk Classification

The IWGDF recommends risk stratification of patients with DFU into 4 groups (**Table 6**). For group 0, which has no polyneuropathy and no PAD, an annual checkup of the foot by a trained specialist is sufficient to identify new risk factors and to be able to treat them accordingly. For Group 1 to 3 patients, there should be an increasing frequency of foot screening with increasing risk levels.[1] Approximately every third patient in the high-risk group will have another ulcer within 1 year, and the incidence for amputation in patients who had a previous amputation is 20% (see **Table 6**).[33]

THERAPY FOR DIABETIC FOOT ULCERS

Antibiotic Therapy

The DFU infections can either be monomicrobial or polymicrobial, with the latter being more common in chronic infections.[34] A recent meta-analysis by Macdonald and colleagues[35] showed that the spectrum of bacteria found is diverse, with *Staphylococcus aureus* being the most commonly isolated organism with the methicillin-resistant strain making up 18% of the total numbers. Other frequently isolated organisms are *Pseudomonas aeruginosa*, *Escherichia coli*, Proteus, and Enterococcus among others. Skin commensals are often detected in superficial microbiological samples, hence, adequate deep tissue biopsies for cultures and antibiotic sensitivity testing should be obtained to guide antibiotic treatment.[36] The choice of antibiotic therapy mainly depends on microbiological findings and antibiotic resistance. Before the organisms and

their antibiotic sensitivities are reported, the SINBAD classification or the IWGDF guidelines can guide our choice of an appropriate empirical antibiotic regime.[36,37]

In the case of a superficial and stable DFU with decent granulation tissue and with no evidence of infection, antibiotic therapy is not indicated, and antiseptic wound dressings are usually sufficient. In the case of mild infections, oral antibiotics are prescribed for 1 to 2 weeks. In the case of high-grade infections with significant systemic and local signs of infection such as fever, tachycardia, hypotension, erythema, warmth, suppuration, wet gangrene, and with significantly deranged laboratory markers such as an elevated C-reactive protein and leukocyte count, admission is indicated. Early intravenous administration of antibiotics under close clinical and laboratory monitoring is recommended.[36,37]

Usually, the empirical administration of antibiotics according to each local hospital's guidelines is started immediately after tissue samples are taken for culture, and the therapy is adapted to the culture results and the antibiotic sensitivities. To avoid a rapidly ascending infection, empirical antibiotic therapy should be started as early as possible, when surgery with adequate biopsies is not possible within 6 to 12 hours. In the most of the cases, this early start of empirical antibiotics does not affect the microbiological diagnosis negatively due to poor vascularization of the diabetic feet. The benefit of preventing an ascending infection, septicemia, and its complications far outweigh the disadvantages of an inaccurate culture sample.

First-line antibiotics are usually clindamycin and/or third-generation cephalosporin or aminopenicillin. If anaerobic bacteria are suspected, metronidazole can be added.[36,37] Relevant secondary diseases such as kidney and liver diseases in diabetic patients must be considered, when choosing the antibiotic and the dosage. The dogma "time is tissue" should not be forgotten. Timely treatment can potentially save more tissue, increase the limb salvage rate, or at least diminish the extent of amputation.[38]

Offloading

Offloading of the affected limb is essential for the healing of a DFU and is best managed in close collaboration with either the orthotist, the shoe technician, or the podiatrist. For plantar ulcers, which are located in the forefoot or midfoot region, patients should be advised to either non–weight-bear or bear weight on their heels and be prescribed with a forefoot offloading shoe. The treatment regime depends greatly on the nature of the ulcer and the surgeon's assessment. If regular dressing changes are required, easily removable shoes or orthoses are worthwhile. For heel ulcers, patients are usually advised to non–weight-bear and may be prescribed a heel-off loading orthosis, which lowers regional pressure best and thus supports wound healing.[39] For offloading devices, there has been a paradigm shift away from using the total contact casts (TCC) to prefabricated knee-high orthoses, which can be made irremovable, such as the instant TCC. Second- and third-line recommendations include removable knee-high devices and removable ankle-high offloading devices, respectively. Some examples of knee-high devices include bivalved TCCs and knee-high walkers and examples of ankle-high devices include offloading shoes and cast shoes.[40] For DFUs that are nonplantar, ankle-high offloading devices such as a cast shoe or shoe modifications such as the addition of inner padding with padded dressings or altering the dimensions of the shoe and toe spacers should be considered, depending on the ulcer location.

Wound Therapy

The current IWGDF guideline[41] recommends debridement of all necrotic nonvital tissue in superficial and deep DFU unless there is dry necrosis. Surgical debridement

should be repeated every 24 to 72 hours if new necrotic tissue arises and if there is still clinical and biochemical evidence of active infection. Negative pressure wound therapy (NPWT) to stimulate wound granulation and improve regional vascularization can be used postoperatively after surgical debridement. However, despite its increasing popularity, the current evidence of NPWT in improving wound healing rates and healing times is still weak. In the case of chronic ulcers, the benefit has not yet been scientifically proven.[41]

DFUs are not homogenous, and there is no "one-for-all" superior wound dressing. There is still an ambivalent study situation, when it comes to the use of specific wound dressings. Therefore, no recommendations should not be made at this point. However, important sound wound management principles should be emphasized.[14,27,41]

Keeping the wound environment optimized is crucial for successful wound treatment.[41] For a long time, the dogma of the dry wound environment was standard in DFU treatment. Except for removing excessive exudate, the dressing should maintain a moist environment to promote granulation and the subsequent healing process.[42] Dry necrosis should be kept dry. Otherwise, necrotic tissue should be removed frequently.[41]

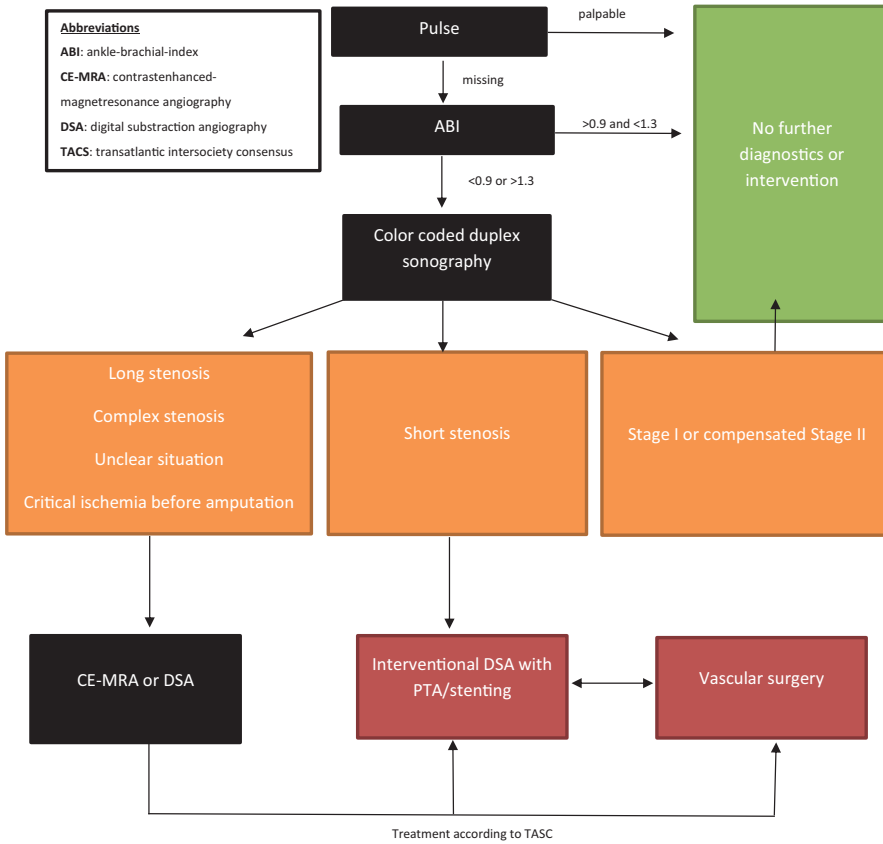
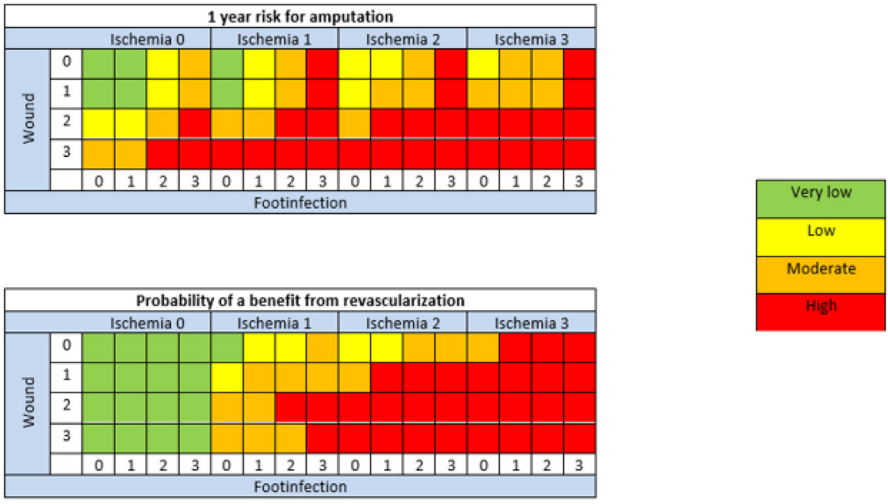


Fig. 1. Simplified diagnostic and therapeutic algorithm for vascular intervention. ABI, ankle-brachial-index; CE-MRA, contrastenhanced-magnetresonance angiography; DSA, digital substraction angiography; TACS, transatlantic intersociety consensus.S (*Data from* Rumenapf et al.[27])



	W Wound	I Ischemia	fi Footinfection
0	No ulcer, no gangrene	ABI>0.8(pressure>100mmHg), TcPO2>60mmHg	No infection
1	Superficial ulcer, no gangrene	ABI<0.8(pressure<100mmHg), TcPO2<60mmHg	Mild infection: swelling, mild erythema, calor
2	Probe to bone/tendon/joint positive or forefoot gangrene	ABI<0.6(pressure<70mmHg), TcPO2<40mmHg	Local infection: erythema >2cm, subcutaneous structures involved
3	Massive ulcer or massive gangrene (for-, mid-, hindfoot)	ABI<0.4(pressure<50mmHg), TcPO2<30mmHg	Severe infection: Local infection with systemic signs SEPSIS, SIRS with

Fig. 2. The WIFI classification correlated with risk of amputation and probability of a benefit from revascularization. (*Data from* Rumenapf et al.[27])

Indications for Vascular Intervention

According to the IWGDF Guidelines,[28] no wound healing tendency within 4 to 6 weeks despite optimal management is an indication for further vascular imaging and revascularization. In addition, toe pressure less than 30 mm Hg, $TcPO_2$ less than 25 mm Hg, or ABI less than 0.5 are indications for urgent vascular imaging and intervention. Although ABI per se cannot be used as a prognostic factor for DFU healing, the amputation risk increases with an ABI less than 0.5 or ankle pressure less than 50 mm Hg.

A simplified diagnostic and therapeutic algorithm is shown in **Fig. 1**.

The WIFI classification is a prognostic tool to identify patients who may benefit from revascularization. It is divided into 3 main categories: wound grade, ischemia grade, and foot infection grade. **Fig. 2** shows the expected outcome of revascularization in the respective population ranging from very low benefit to high benefit.

In patients with DFU with symptomatic PAD, conservative treatment is recommended when there is either no strong indication for vascular intervention, the risk of intervention is too high, or intervention failed. The medical treatment regime includes the administration of antiplatelets (aspirin, 100 mg, or clopidogrel, 75 mg, daily) and the administration of statins and a structured vascular exercise program.[27,28]

PREVENTION OF DIABETIC FOOT ULCERS

Education for Patients and Relatives

Preventive education programs for patients and relatives are an integral part of the management of diabetes mellitus in many countries around the world and are well

established. Although patient education to prevent DFUs has not been proved by randomized controlled trials,[43] individual studies report lower ulcer[44] and amputation rates.[14] Despite low-quality evidence, the IWGDF guidelines strongly support patient instruction not to walk barefoot, not to walk only in socks or thin slippers, and to wear suitable shoes made for diabetic feet lacking sensation. Furthermore, instruction of daily self-examination and regular self-care to prevent ulcers is recommended.[45] Some self-care strategies include keeping feet clean, ensuring skin between the toes is kept dry, using emollients to moisturize dry skin, and cutting toenails straight across.[11]

Shoe Wear

The consistent use of appropriate shoe wear should be checked at each clinical visit and incorporated into the patient education as well. Poorly fitting or inappropriate shoe wear may cause pressure concentration and repetitive trauma, which may lead to inflammation, soft tissue breakdown, and surprisingly rapid to DFU.[46] Diabetic polyneuropathy impairs not only the sensory but also the motor nerves and results in muscle imbalance of the foot. Common deformities due to muscle imbalance include equinus, hammertoes, claw toes, and even cavus feet.[47] These deformities are significant risk factors for DFU and also impede healing because of abnormal pressure concentration. For patients with deformities and who are at risk for ulceration, therapeutic shoes, custom-made insoles, or toe orthosis should be prescribed.[48] Off-the-shelf shoe wear with a wide toe box is sufficient for patients without severe foot deformity and polyneuropathy and thus with a low risk of DFU. However, regular reevaluation of the footwear and risk class is essential.[45]

Detection and Treatment of Preulcers

Prevention begins with the identification of preulcer lesions, which can manifest as hyperkeratosis, blisters, and infections. Regular monitoring and podiatry treatment with removal of the hyperkeratosis combined with various offloading modalities are recommended.[14] The relief of abnormal pressure areas reduces the risk of progression to DFUs.[45]

Preventive Surgical Measures and Perioperative Optimization

In the presence of foot deformities that cannot be adequately treated conservatively, surgical off-loading can be considered as a preventive measure.[45] The surgical techniques are wide-ranging, from flexor digitorum longus tenotomy in claw toes and exostectomies to complex reconstruction, for example, in severe deformities associated with Charcot arthropathy.[14,27] A surgical risk assessment should always be carried out before considering an elective surgical procedure. In addition to the usual surgical risks, asymptomatic PAD should be considered in order to avoid wound healing disorders.[27] Furthermore, perioperative hyper- and hypoglycemia should be avoided. Continuous glucose monitoring is of major importance to avoid those dysglycemic states and secondary complications.[49]

SUMMARY

Interdisciplinary treatment of diabetic patients ranging from basic local primary care to highly specialized IDFCs in tertiary hospitals should be the gold standard based on current evidence. A graded care team helps to triage patients with DFUs, optimizes medical resources, and reduces costs. Evaluation of team composition and improvement of the therapeutic and preventive algorithm should be the aim of further studies.

CLINICS CARE POINTS

- The interdisciplinary diabetic foot clinic (IDFC) should comprise of members with expertise in diabetic patient management working together on-site.
- The composition of IDFC cannot be generalised and should be optimised based on the individual hospital requirements, workflow, infrastructure and available expertise.
- The IDFC should have clinic-specific algorithms or pathways to help optimize each patient visit.
- The IDFC's access to various members of the interdisciplinary team should be readily available. For example, the infectious disease specialist for multidrug-resistant bacteria infection.

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