THE UNIVERSITY OF JORDAN | School of MEDICINE

Surgical Aspects of Diabetic Foot

Nidal A Younes, MBBSc, MA, TSRF
Professor Endocrine Surgery, Diabetic Foot Specialist
Jordan University Hospital

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Edited by : Haya khader

Diabetic foot

- Diabetic foot is a disease complex that can develop in the skin, muscles, or bones of the foot as a result of the nerve damage, poor circulation and/or infection that is associated with diabetes

pathophysiology --> begin with neuropathy (sensory / motor / autonomic)+ peripheal arterial disease (complicate the problem) --> muscle waste / loss of sensation

Spectrum of DF

Spectrum of DF

IWGDF Definitions

international working group of diabetic foot

- **IWGDF (2019) - Diabetic foot:** Infection, ulceration, or destruction of tissues of the foot of a person with currently or previously diagnosed diabetes mellitus, usually accompanied by neuropathy and/or PAD in the lower extremity.

- **IWGDF (2023) - Diabetes-related foot disease**: Disease of the foot of a person with current or previously diagnosed **diabetes mellitus** that includes *one or more of the following*:

Peripheral Neuropathy

Infection

Neuro-osteoarthropathy

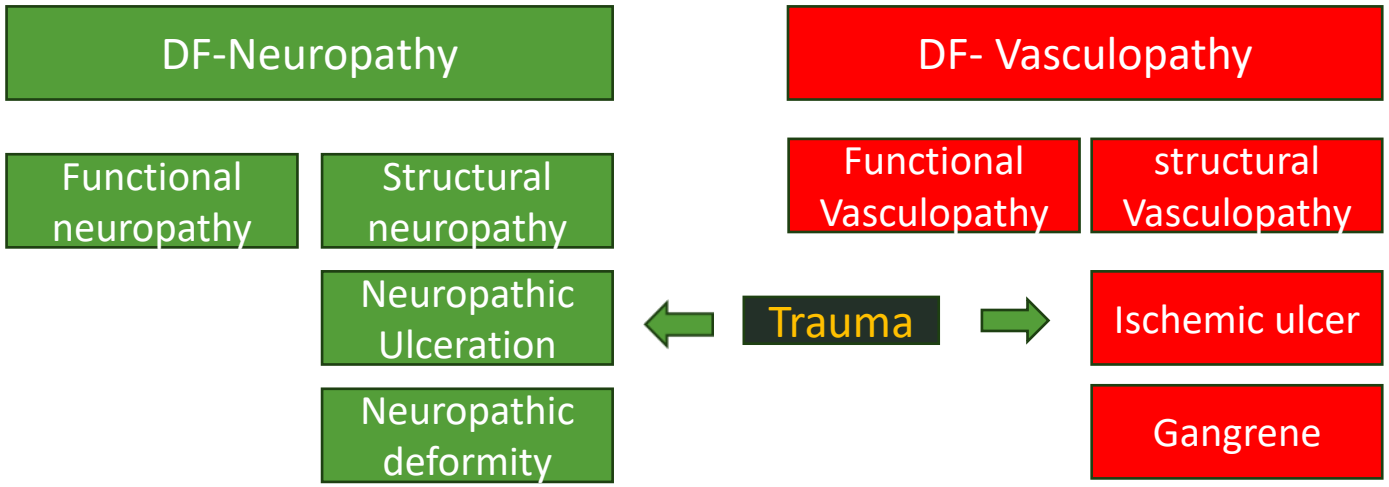
Amputation

Peripheral Artery Disease

Ulcer(s)

Gangrene

Diabetic Foot



IWGDF

International Working Group on the Diabetic Foot

- IWGDF practical guidelines describe the basic principles of prevention and management of diabetic foot disease.
  - Most recent guidelines issued in **2023**

IWGDF Guidelines

References


IDF Clinical Practice Recommendations
on the Diabetic Foot – 2017
A guide for healthcare professionals
International
Diabetes
Federation


Prevention and Management of
Foot Problems in Diabetes
Guidance Documents and Recommendations
GUIDANCE
ON THE DIABETIC FOOT
The 2015 challenge of the
International Working Group
on the Diabetic Foot
IWGDF
Guidance


Diabetes/Metabolism
Research and Reviews

Magnitude of the DFU

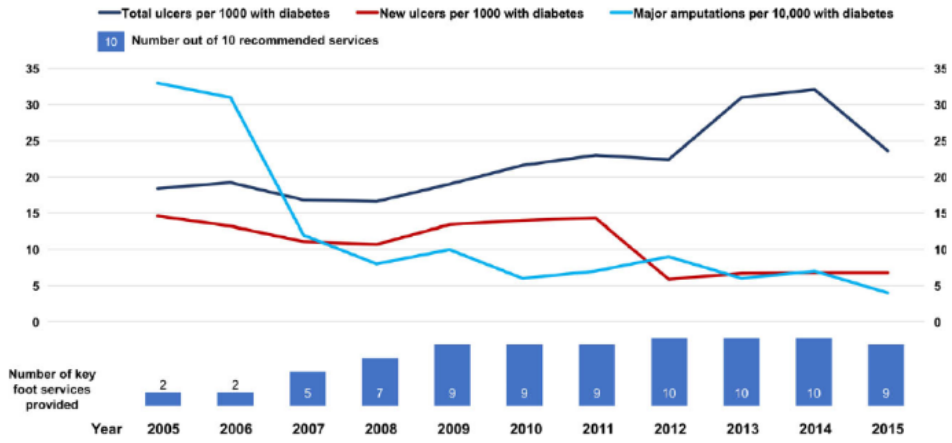


FIGURE 1 Diabetes-related foot ulcer prevalence and incidence, and major amputation incidence in the period 2005 to 2015 in South Devon as improved key services were introduced. Columns show service provision. Reduction in amputation over time, P=0.0115, z value= –2.526, residual deviance = 3.4 using a Poisson regression of log-transformed number of major amputations with a right-side offset of patient population by year using statistical software 'R'.

4-10% prevalence of ulcers among diabetic patients

50% of ulcers get infected

20% hospitalized

20%

- One amputation every 19 seconds, major amputation every 53 seconds

Magnitude of the DFU

every 30 seconds , a lower limb is lost somewhere in the world as a consequence of diabetes

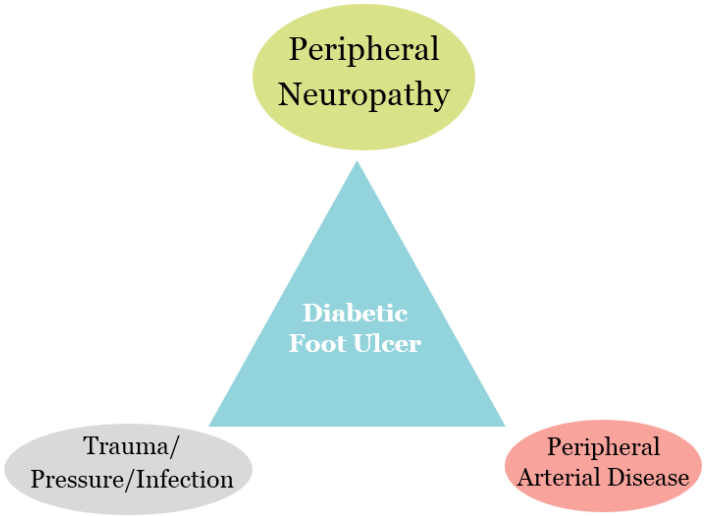
5-year mortality rate after limb amputation is **68%**

5-year mortality of some cancers:

- Lung: 86%
- Colorectal: 39%
- Breast: 23%
- Hodgkin's Lymphoma: 18%
- Prostate cancer: 8%

DFU-etiology

- Neuropathy
- Ischemia
  - Infection
  - abnormal foot structure and biomechanics
  - Weak **healing** power



Pathophysiology

Chronically poor glycemic control

Peripheral Neuropathy

Sensory

- Decreased **pain** sensation → Exposure to injury without noticing
- Decreased **pressure** sensation → Pressure injury goes unnoticed
- Decreased **temperature** sensation → Repetitive thermal injury
- Decreased **proprioceptive** sensation → Susceptibility to falls

Motor

Small muscle **wasting**

↓

Foot **deformity**

↓

Causes **pressure points** and biomechanical abnormalities

Autonomic

Decreased sweating causing dry skin and susceptibility to injury

Peripheral Arterial Disease

Ischemia causes poor wound healing and contributes to tissue necrosis

Diabetic foot/peripheral neuropathy

- The presence of symptoms or signs of peripheral nerve dysfunction in people with diabetes, after exclusion of other causes
  - Signs and symptoms
  - Tissue loss (ulceration)

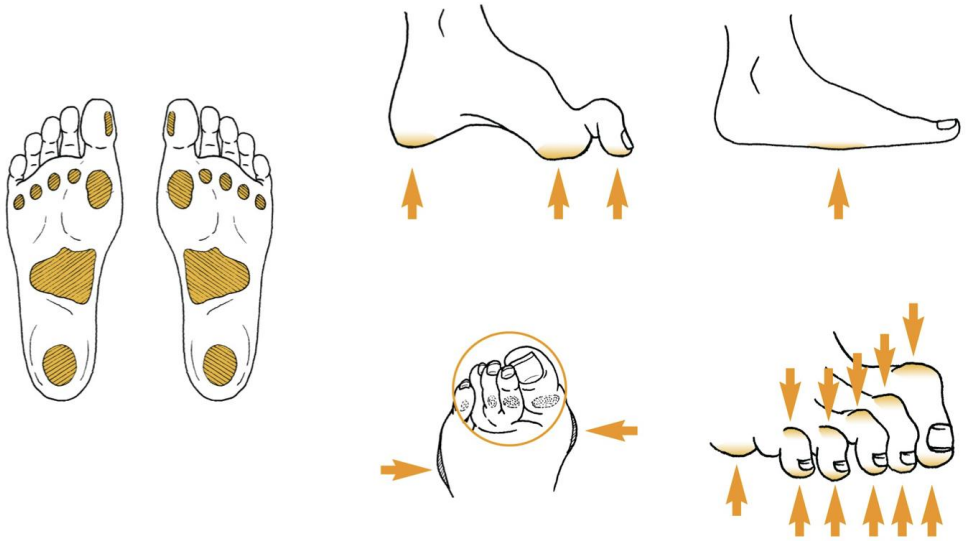
Neuropathic Ulcers

granulation tissue surrounded by callus in edges and margins of ulcer
characterized by its location (natural pressure point)
painless (not in all patient)

due to loss of sensation / wasting / dryness --> with repetitive trauma lead to this ulcer

- Diabetic foot ulcers most commonly occur at **sites** of **pressure and repetitive stress**:
  - Plantar metatarsal heads
  - Heel
  - Dorsal portion of the toes
- Clinical features
  - Usually painless (due to neuropathy)
  - Thick callus surrounding ulcer

Figure 2: Areas of the foot at highest risk for ulceration



Who to examine for foot disease?

- **All patients with diabetes** should undergo basic examination of the foot regularly.
- At each visit, the following should be performed:

1. History & Physical Exam, including:
   - Foot Inspection
   - Clinical neurologic exam
   - Clinical vascular assessment
2. Risk Assessment
3. Foot Care Education & Preventive Measures

1. Foot Exam - Overview

History	Physical Exam
History pertaining to diabetes	**Inspection** (check between toes!)
Duration of DM & glycemic control	**Dermatologic:**
Complications of diabetes (cardiovascular, **end-stage renal disease**, etc.)	Skin color, dryness, cracking, sweating, toenails, hair, calluses, blistering, foot hygiene
Symptoms of micro- & macrovascular disease	Signs of infection (erythema, swelling, discharge), check between toes!
Neuropathy: burning, paresthesias, etc	Ulcers or pre-ulcerative lesions (e.g., fissures, hemorrhage)
PAD: lower limb claudication	**Musculoskeletal:**
History of diabetes-related foot disease	Foot deformities (claw or hammer toes, Charcot joint) and muscle wasting
Previous ulcer/ Previous amputation	neurologic and vascular assessment

Neurologic Assessment

- Loss of protective sensation (LOPS): assess with one of the following techniques:
  - Light pressure perception: **Semmes-Weinstein 10-gram monofilament**
  - Vibration perception: **128 Hz tuning fork**
  - When monofilament or tuning fork are not available, test tactile sensation with **Ipswich touch test** (lightly touch the tips of the toes of the patient with the tip of your index finger for 1–2 seconds)

Semmens-Weinstein 10g Monofilament

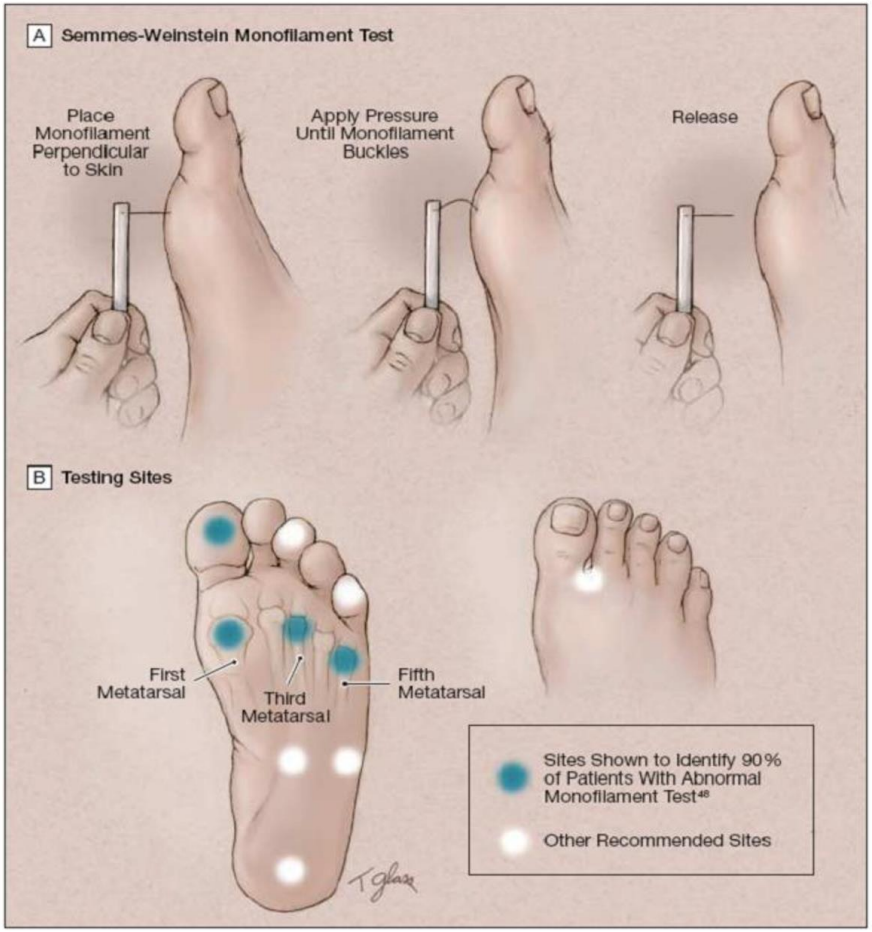
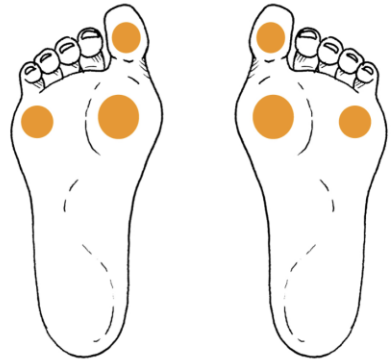
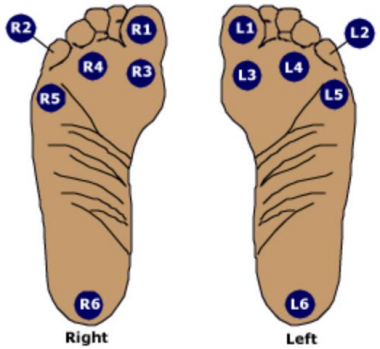


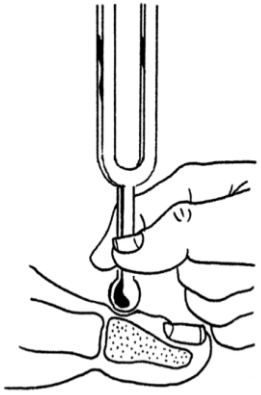
Figure 4: Sites that should be tested for loss of protective sensation with the 10g Semmes-Weinstein monofilament





Other tests

Figure 6: Proper method of using a 128 Hz tuning fork to check for vibratory sensation



128 Hz Tuning fork

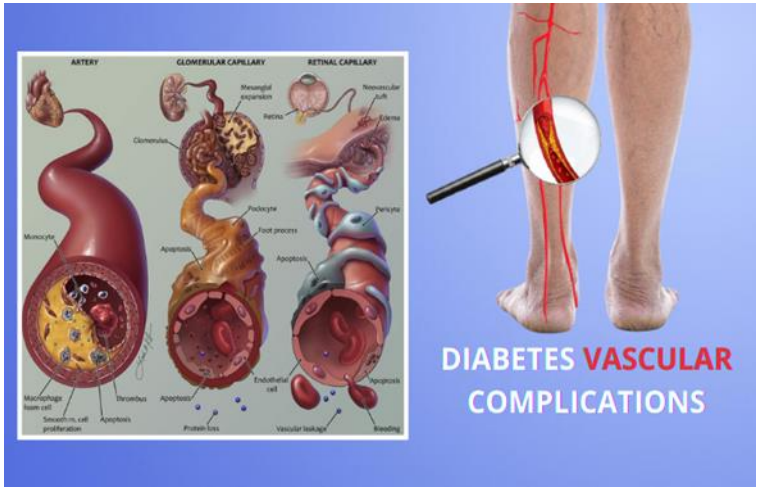
Ipswich touch test

+++REFLEXES
ankle reflex and knee jerk reflex
-neurologic exam of the lower limbs may also include assessment of reflexes

Peripheral vascular disease

- Obstructive atherosclerotic vascular disease with clinical symptoms, signs or abnormalities on non-invasive vascular assessment, resulting in disturbed or impaired circulation in one or more extremities

2015 International Working Group on the Diabetic Foot



Vascular Assessment

- Assessment of **pedal pulses**
  - Dorsalis pedis: Lateral to external hallucis longus tendo
  - Posterior tibial artery: posterior to medial malleolus
  - If absent, assess popilteal and femoral pulses
- Assess **temperature, skin hair**
- Assess for dependent rubor (late finding) reddish-purple discoloration of the lower extremities that occurs when the affected limb is in a dependent (hanging down) position, such as when the legs are dangling off a chair or bed.
- If exam findings suggest PAD, proceed with ankle-brachial index (ABI) or toe-brachial index (TBI)

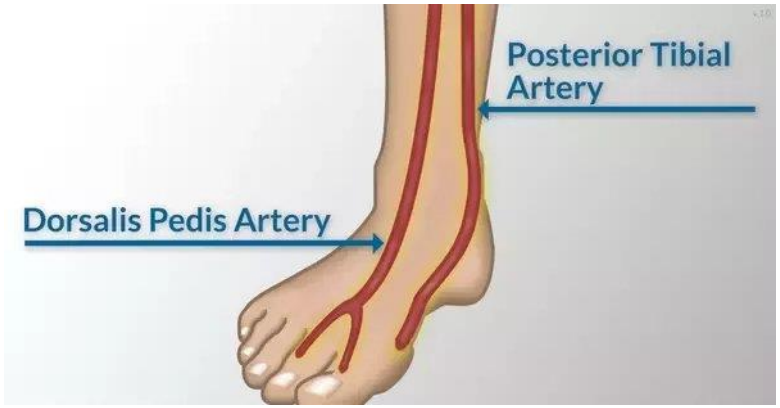


Table 4. Interpretation of the Results of Ankle-Brachial Index Measurement

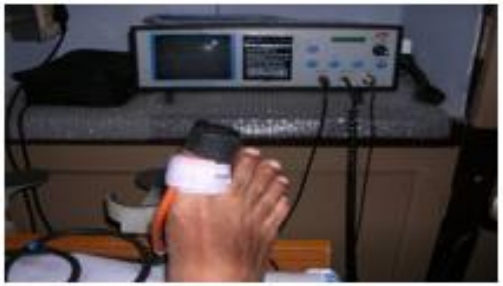
ABI[a]	Interpretation
>1.30	Poorly compressible vessels, arterial calcification
0.90–1.30	Normal
0.60–0.89	Mild arterial obstruction
0.40–0.59	Moderate obstruction
<0.40	Severe obstruction

Abbreviation: ABI, ankle-brachial index.

[a] Obtained by measuring the systolic blood pressure (using a properly sized sphygmomanometer) in the ankle divided by that in the brachial artery. The presence of arterial calcification can lead to an overestimate in the index.

Vascular assessment

- Noninvasive
  - ABI ankle-brachial index
  - Duplex studies
  - Tco2
  - Systolic toe pressure
- CT-angiograms



Foot At risk: Assessment

- Following examination of the foot, **stratify each patient using the IWGDF risk stratification category system** shown below to guide subsequent preventative screening frequencies and management.

Table 1: The IWGDF 2023 Risk Stratification System and corresponding foot screening frequency

Category	Ulcer risk	Characteristics	Frequency*
0	Very low	No LOPS and no signs of PAD	Once a year
1	Low	LOPS or PAD	Once every 6-12 months
2	Moderate	LOPS + PAD, or LOPS + foot deformity or PAD + foot deformity	Once every 3-6 months
3	High	LOPS or PAD, and one or more of the following: - history of a foot ulcer - a lower-extremity amputation (minor or major) - end-stage renal disease	Once every 1-3 months

assess the foot every year

Note: LOPS = Loss of Protective Sensation; PAD = Peripheral Artery Disease; * Screening frequency is based on expert opinion, since there is no published evidence to support these intervals

How can we prevent foot ulcerations?

- Identify the person with an **at-risk foot** by test the sensations and vascularity
- **Regularly inspect and examine** the feet of a person at-risk for foot ulceration.
- Provide **structured education** for patients, their family and healthcare professionals
- Encourage routine wearing of **appropriate footwear**
- **Treat risk factors** for ulceration
- **Integrated foot care**, which is a combination of these elements.

What is Structured Education?

- General instructions
  - Good glycemic control
  - Avoid smoking
- Patients with IWGDF grade ≥ 1
  - Avoid going barefoot, even at home, and especially on hot decks and hot sand
  - Test water temperature before stepping into a bath
  - Trim toenails to shape of the toe, and remove sharp edges with a nail file; do not cut cuticles
  - Wash in lukewarm water, dry thoroughly (including between the toes), and check feet daily
  - Socks should fit and be changed daily

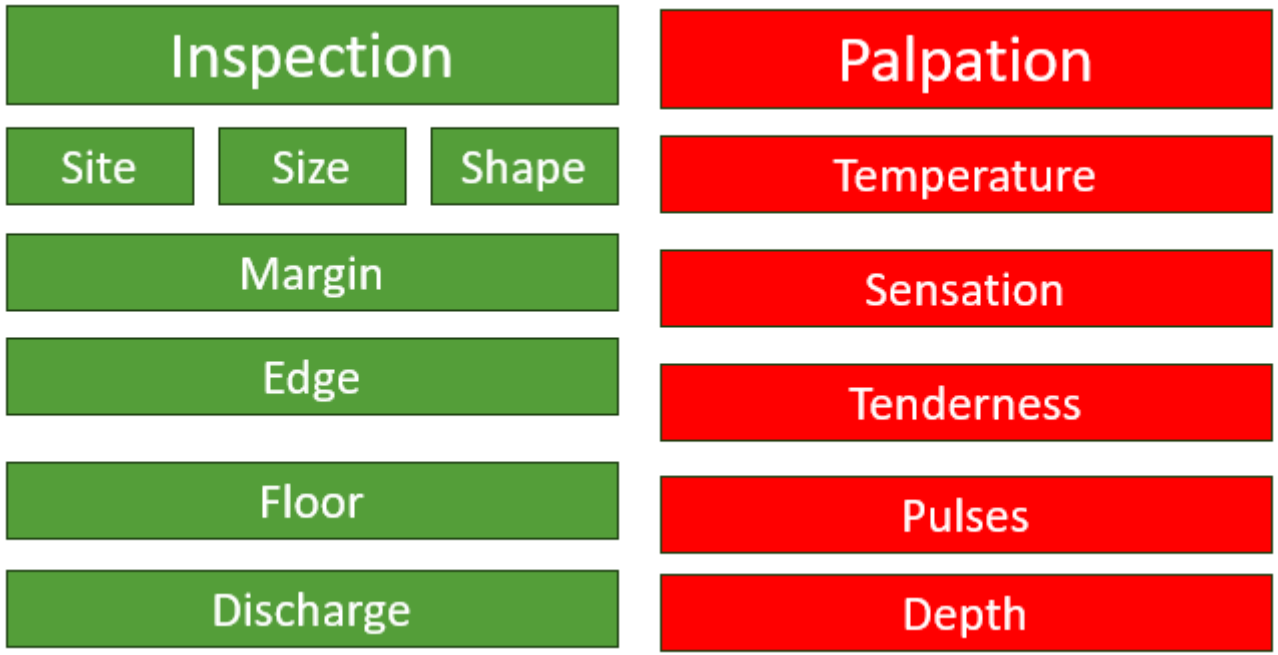
Appropriate Footwear

- In persons with diabetes and IWGDF risk category 1 or higher:
  - Encourage to wear appropriate footwear at all times, both indoors and outdoors.
- Criteria for appropriate footwear
  - Inside length of the shoe should be 1-2 cm longer than the foot and should not be either too tight or too loose.
  - Internal width should equal the width of the foot at the metatarsal phalangeal joints (or the widest part of the foot), and the height should allow enough room for all the toes.

Treat Risk Factors

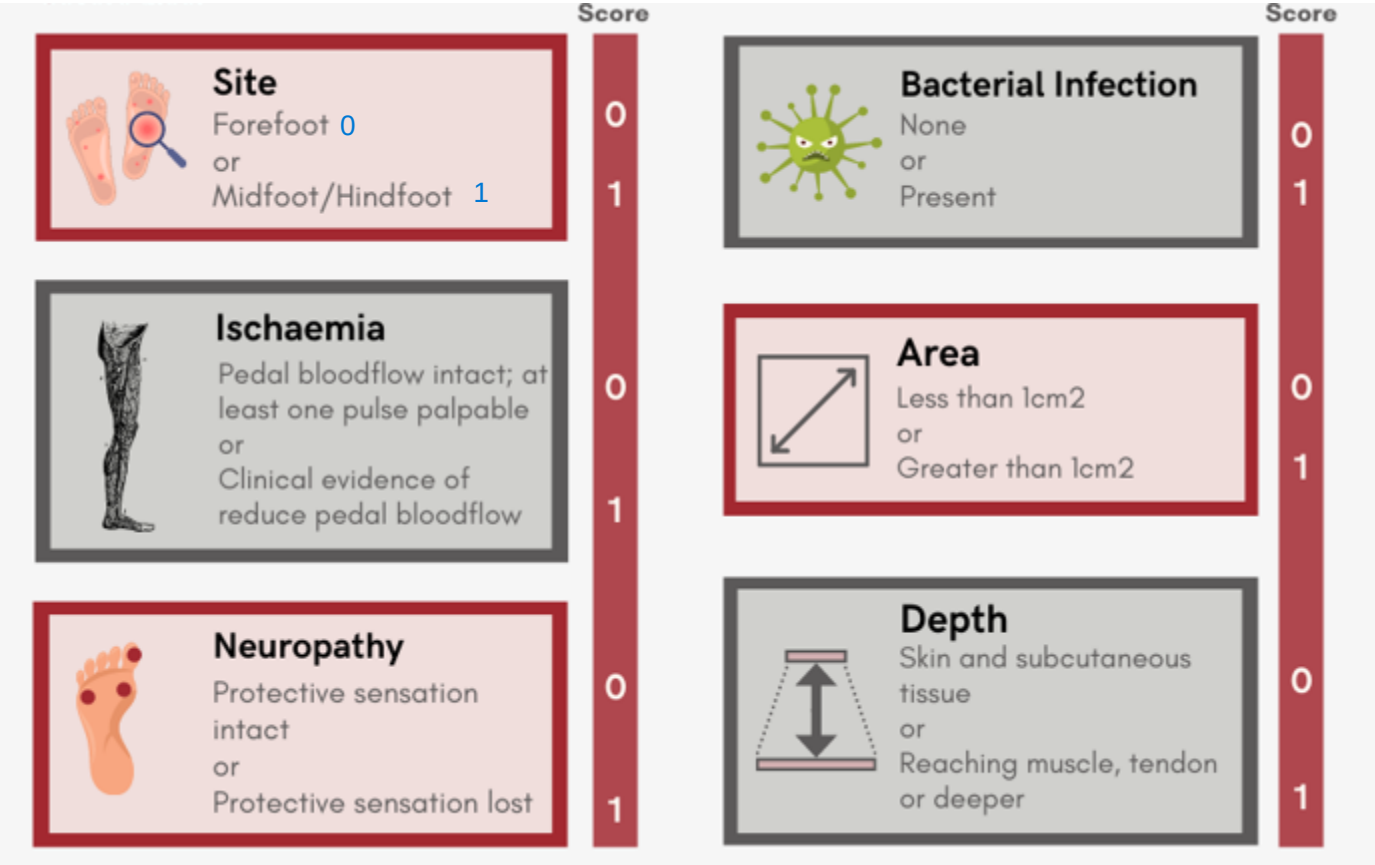
- Provide appropriate treatment of **excess callus** on the foot, for **ingrown toenails**, and for **fungal infections** on the foot. Treat any (modifiable) **pre-ulcerative** sign on the foot including protecting blisters, or draining them if necessary.
- Consider coaching a person with diabetes who is at moderate or high risk of foot ulceration (IWGDF risk 2-3) to **self-monitor foot skin temperatures** once per day to identify any early signs of foot inflammation and help prevent a foot ulcer.
  - In case of an elevated temperature, ambulatory activity should be reduced
- The risk for foot ulceration is not a barrier to participating in a physical training program as long as appropriate footwear is worn, with a gradual increase in activity to an additional 1000 steps/day.

Assessment of Ulcers



site / ischemia / neuropathy / bacterial infection / area / depth

SINBAD score



IDSA/IWGDF System

Table 4: IDSA/IWGDF system

Clinical manifestations	Infection severity	PEDIS grade
Wound lacking purulence or any manifestations of inflammation	Uninfected	1
Presence of ≥ 2 manifestations of inflammation (purulence, or erythema, tenderness, warmth, or induration), but any cellulitis/erythema extends ≤ 2cm 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 which has ≥ 1 of the following characteristics: cellulitis extending >2cm, 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 (e.g. fever, chills, tachycardia, hypotension, confusion, vomiting, leucocytosis, acidosis, severe hyperglycaemia, or azotaemia)	Severe	4

Principles of Ulcer Treatment

1. Treatment of infection.
2. Restoration of tissue perfusion. to promote healing
3. Pressure offloading and ulcer protection. remove the pressure
4. Local ulcer care.
5. Person Centered Care.
6. Education for patient and relatives.

1. Treatment of Infection

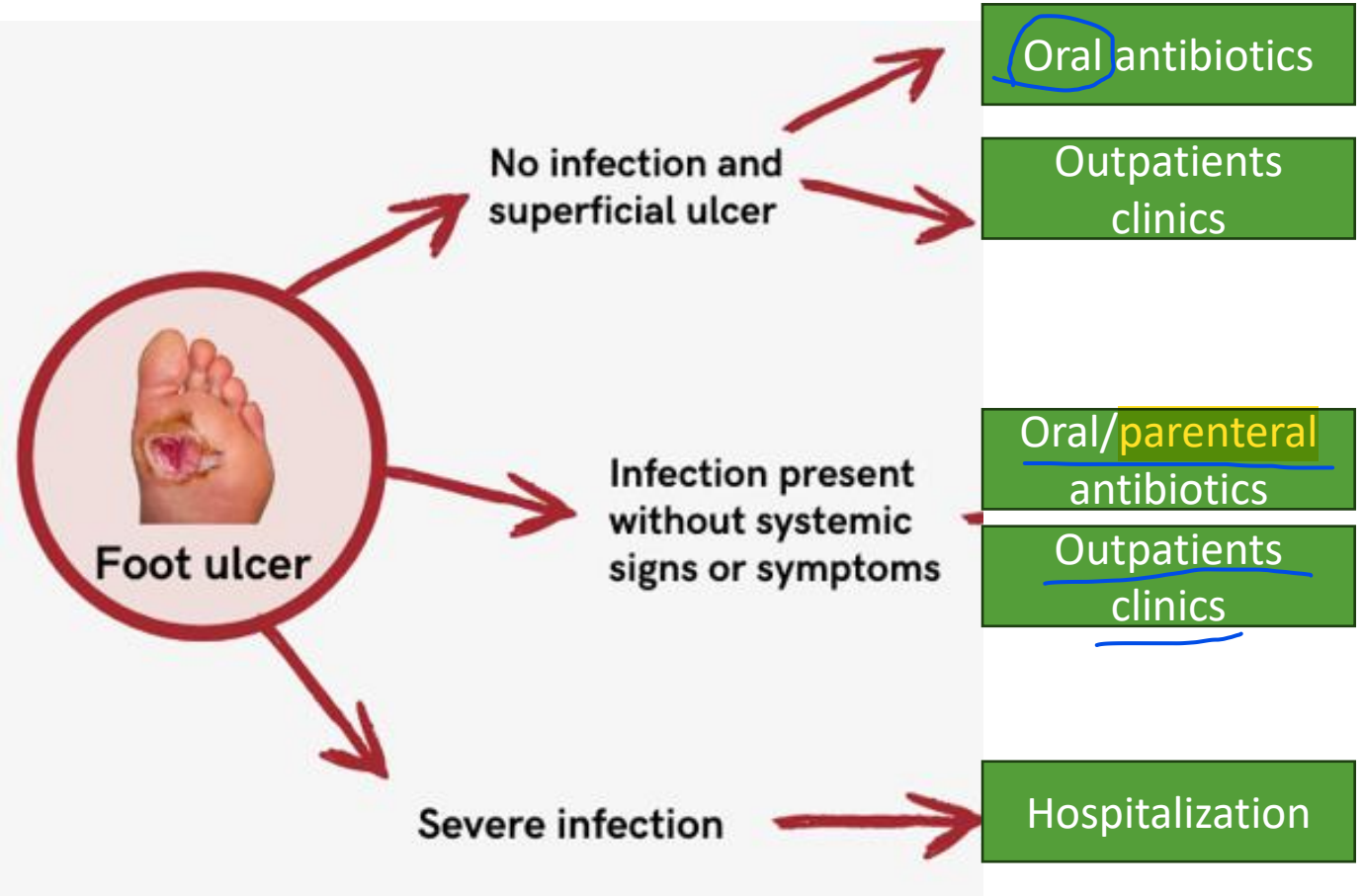
skin or superficial subcutaneous tissue

- **Superficial ulcer with limited soft tissue (mild) infection: (1-2w)**
  - Cleanse, debride all necrotic tissue and surrounding callus.
  - Start empiric oral antibiotic therapy targeted at Staphylococcus aureus and streptococci (unless there are reasons to consider other, or additional, likely pathogens).
  - We can use clindamycin , cephalexin , amox-clav , doxycycline.

1. Treatment of Infection

- **Deep or extensive (potentially limb-threatening) infection (moderate (+/-IV abx) or severe (+IV abx)): (2-3w)**
  - Urgently evaluate for need for surgical intervention to remove neurotic tissue, including infected. Bone, release compartment pressure or drain abscesses.
  - Assess for PAD; if present consider urgent treatment, including revascularization.
  - **Initiate empiric, parenteral, broad-spectrum antibiotic therapy**, aimed at common gram-positive and gram-negative bacteria, including obligate anaerobes.
    IV or IM
  - Adjust (constrain and target, if possible) the antibiotic regimen based on both the clinical response to empirical therapy and culture and sensitivity results.

Managing foot infections



2. Restoration of Tissue Perfusion

- Revascularization If:
  - An ankle pressure <50mm Hg or an ABI <0.5 then consider urgent vascular Imaging
  - A toe pressure is <30mmHg or TcpO2 is <25 mmHg.
  - When an ulcer falls to show signs of healing within 6 weeks, despite optimal management
- The aim of revascularization:
  - to restore direct flow to at least one of the foot arteries, preferably the artery that supplies the anatomical region of the wound.
- Select a revascularization technique based on both individual factors (the patients factor and the local operator expertise).

3. Pressure offloading and ulcer protection

to remove the weight of the person to prevent the pressure

to remove the pressure on ulcer and enhance healing

- Non removable knee-high offloading device
  - A total contact cast (TCC)
- Removable knee-high offloading device.
- Ankle-high offloading device.
- If biomechanical relief are not available using felted foam

but only in combination with appropriate footwear

Total Contact Cast

Removable knee-high offloading device

Ankle-high offloading device

4. Local Ulcer Care

- Regular inspection of the ulcer by a trained health care provider is essential.

before debridement of necrotic tissues we do drainage

- Debride the ulcer and remove surrounding callus (preferably with sharp surgical instruments) and repeat as needed.

- Select dressings to control excess exudation and maintain moist environment.

- Do not soak the feet, as this may induce skin maceration.

- Consider negative pressure to help heal post-operative wounds.

4. Local Ulcer Care

- **Consider one of the following adjunctive treatments in non-infected ulcers that fail to heal after 4-6 weeks despite optimal clinical care:**
  - A sucrose octasulfate impregnated dressing in neuro-ischemic ulcers (without severe ischemia).
  - A multi-layered patch of autologous leucocytes, platelets and fibrin in ulcers with or without moderate ischemia.
  - Placental membrane allografts in ulEers with or without moderate ischemia.
  - Systemic oxygen therapy as an adjunctive treatment in ischemic ulcers that do not heal despite revascularization.

Diabetic foot / healing issues

- Multifactorial in origin
- Local tissue ischemia in addition to neuropathy impairs chemotaxis.
- Tissue necrosis and infection prolongs the inflammatory phase of healing.
- Uncontrolled periwound edema and wound instability disrupts myofibroblast.
- Glycation of proteins
- Associated PVD

Diabetic foot / healing issues

- Clean ulcers regularly with clean water or saline, debride them when possible in order to remove necrotic tissue from the wound surface and dress them with a sterile, inert dressing.

- We should promote healing process by controlling excessive exudate and maintain a warm, moist environment.

5. Person Centered Care

- Optimise glycaemic control, if necessary, with insulin.
- Treat oedema or malnutrition, if present.
- Treat cardiovascular risk factors.
- Treat depression or other psycho-social difficulties.

Surgery indications

Emergency

- To limit progression of acute infection. incision and drainage. derbridement
- To limit progression of acute ischemia. (necrotizing fasciitis)

Elective

- Promote healing (convert chronic wound to acute)
- Vascular surgery (stenting , angioplasty , ballooning)
- Skin grafting

Prophylactic

- To treat joint stiffness.
- Deformity.

Charcot/ Neuro-osteoarthropathy (CNO)

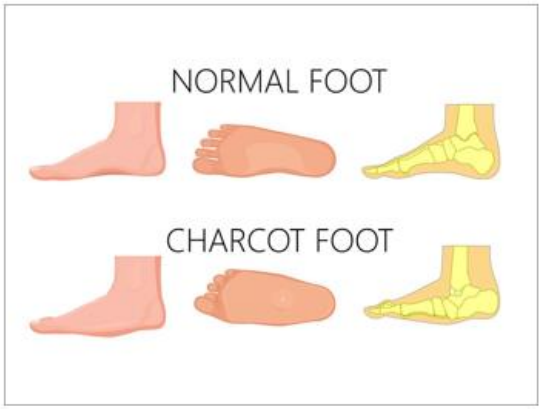
Progressive and destructive: The bones weaken and may fracture or dislocate, often without the person noticing due to lack of pain.

Common signs:
Swelling Redness Increased warmth of the foot (often mistaken for infection)
In later stages: deformity (e.g., "rocker-bottom foot")

- Neuropathic arthropathy (triad) is a sterile inflammatory process in persons with neuropathy (most commonly diabetic neuropathy) that results in the development of bone destruction, subluxation/dislocation, and deformity.
- 1-2:1000
- The tarsus and tarsometatarsal joints are most commonly affected.
- Clinical presentation depends on the stage.

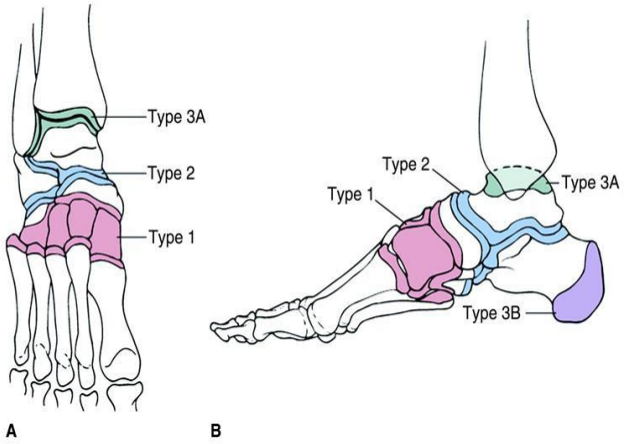
Active Charcot Neuro-osteopathy (CNO)

- **Acute stage:**
  - Swelling, warmth, erythema
  - Pain is typically mild-to-moderate, as the underlying peripheral neuropathy reduces sensation.
  - **Subacute stage:**
- **Chronic stage:** painless bony deformities, midfoot collapse (rocker-bottom foot deformity), osteolysis, fractures.



Brodsky classification/Anatomy

Brodsky Classification	
Type 1	Involves tarsometatarsal and naviculocuneiform joints
Type 2	Involves subtalar, talonavicular or calcaneocuboid joints
Type 3A	Involves tibiotalar joint
Type 3B	Follows fracture of calcaneal tuberosity
Type 4	Involves a combination of areas
Type 5	Occurs solely within forefoot



Eichenholtz classification /pathology

Stage	Radiographic findings	Clinical findings	Treatment
0 (prodromal)	Normal radiographs	Swelling, erythema, warmth	Patient education, serial radiographs to monitor progression, protected weightbearing
I (development) acute	Osteopenia, fragmentation, joint subluxation or dislocation	Swelling, erythema, warmth, ligamentous laxity	Protected weightbearing with total contact casting or prefabricated pneumatic brace. Cast or brace should be used until radiographic resolution of fragmentation and presence of normal skin temperature (usually needed for 2–4 months).
II (coalescence) sub-acute	Absorption of debris, sclerosis, fusion of larger fragments	Decreased warmth, decreased swelling, decreased erythema	Total contact casting, prefabricated pneumatic brace, Charcot restraint orthotic walker, or clamshell ankle-foot orthosis
III (reconstruction) chronic	Consolidation of deformity, joint arthrosis, fibrous ankyloses, rounding and smoothing of bone fragments	Absence of warmth, absence of swelling, absence of erythema, stable joint ± fixed deformity	Plantigrade foot: custom inlay shoes with rigid shank and rocker bottom sole. Nonplantigrade foot or ulceration: débridement, exostectomy, deformity correction, or fusion with internal fixation.

Stages I-III described by Eichenholtz, Stage 0 added by Shibata et al. [21], because clinical signs of Charcot arthropathy were found to precede radiographic changes.

Management

- **Acute phase**: 0-3 months (acute, development-fragmentation).
  - Treatment must start as soon as possible.
  - The foot must be immobilised in a plaster cast or DH walker
  - Weight must be kept off the foot so you may need to use crutches or a wheelchair.
- **Healing phase**: 4-8 months (**sub-acute**, coalescence).
  - The bones are starting to heal and fuse back together.
  - Some weight can be put on the foot.
  - The foot must remain in the plaster cast or walking brace.
- **Rehabilitation**: 8 month+ (**chronic**)
  - Gradual Wight bearing.
  - special insoles and shoes that support the foot and allow for any changes that have occurred in the shape of the foot.
  - **Surgery** is usually reserved for joint instability or severe deformity.