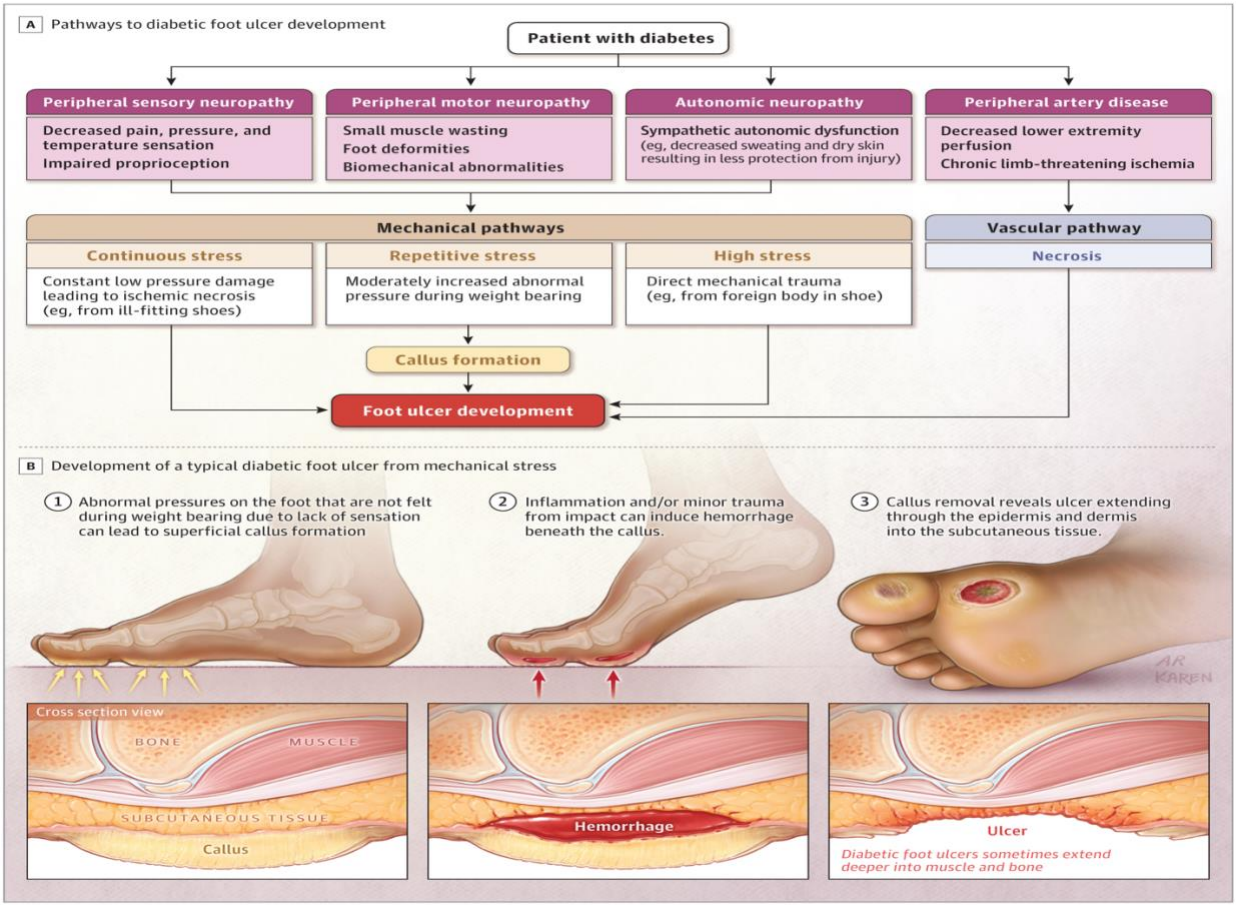
Diabetic Foot Ulcer (DFU) Pathway

Approximately 18.6 million people worldwide are affected by a diabetic foot ulcer each year. These ulcers precede 80% of lower extremity amputations among people diagnosed with diabetes and are associated with an increased risk of death. Approximately 50% of ulcers become infected, with up to 20% of these requiring hospitalization; between 15% and 20% of moderate to severe infections eventually lead to a lower-extremity amputation. People with a diabetic foot ulcer have a 5-year mortality rate of 30%, with a mortality rate greater than 70% for people with an above-foot amputation.

According to the International Diabetes Federation, India had an estimated 77 million adults living with diabetes in 2019, and this number is expected to rise to 101 million by 2030. Up to approximately 34% of people with type 1 or 2 diabetes develop a foot ulcer during their lifetime. This incidence is similar when reviewing the limited published data from India.

Why do ulcers develop?



Screening for DFU

Individuals with diabetes are assessed for loss of protective sensation as a sign of large fiber neuropathy.

1. The Semmes-Weinstein 5.07 monofilament test to assess for absence of pressure sensation at a minimum of 3 sites per foot (likelihood ratio for ulceration range, 11-16) OR
2. the 128-Hz tuning fork to assess for absence of vibratory perception (using an on-off technique or timed methods; likelihood ratio range, 16-35) are important components of this assessment.
3. In the absence of this equipment, the Ipswich Touch Test is an acceptable alternative that can be used to evaluate whether a patient can perceive light touch from an examiner's index finger applied to 6 or 8 prespecified sites on the feet (likelihood ratio range, 10-15)

Physical exam in patients with DFU

General
Physical examination should include evaluation for calluses, interdigital maceration, and thickened nails, which may indicate a fungal infection and may be associated with increased pressure on the nail bed.

Digital deformities such as hammer toes or claw toes appear as increased prominence of the interphalangeal joints dorsally and the metatarsal heads on the plantar surface and are common sites of ulceration. The tip of a toe exposed to increased pressure in contact with the ground or shoe is also a common site of ulceration. Assessment of dorsiflexion and plantarflexion ankle range of motion can identify equinus deformity (ie, less than 0 degrees of dorsiflexion at the ankle joint), which increases forefoot plantar pressure. In a prospective study of 1666 people with diabetes, equinus deformity was present in 10.3% . Charcot arthropathy, defined as a foot fracture with possible joint dislocation in people with peripheral neuropathy, affects approximately 0.3% of people with diabetes, can lead to significant deformity, and increases the risk of a diabetic foot ulcer, particularly in the midfoot and ankle/hindfoot. Although approximately 40% of people with Charcot arthropathy have concomitant tissue loss, a unilateral red, hot, swollen foot without a wound or diagnosis of deep vein thrombosis may indicate Charcot arthropathy.

Pulse palpation at the ankle and on the foot is a central part of the vascular examination, but palpable pulses have low sensitivity (71.7%) and specificity (72.3%) for detecting peripheral artery disease. Because peripheral artery disease affects approximately half of people with diabetic foot ulcers, clinicians should consider noninvasive testing with the ankle-brachial index.

Ulcer assessment
The Wound, Ischemia, Foot Infection (WIfI) classification system was developed and validated as a method to combine all 3 variables (wound, ischemia, and foot infection) and to accurately assess the risk of limb loss for patients with diabetic foot ulcers.

Wound: Degree of tissue loss, class 1- small/shallow; class 2 exposed bone/joint/tendon; class 3 extensive deep wound may/may not involve the calcaneum

Infection: The diagnosis of diabetic foot infection is primarily based on clinical assessment and is suggested by presence of more than 2 signs of inflammation, such as erythema, swelling and possibly purulence, fluctuance, or lymphangitis.
DO NOT OBTAIN WOUND CULTURES: Randomized clinical trial data are not available to support obtaining wound cultures from all patients with diabetic foot ulcers
An erythrocyte sedimentation rate greater than 70 mm/h can be helpful in improving diagnostic accuracy for osteomyelitis (likelihood ratio, 11)
Particularly among hospitalized patients, for whom the pretest probability of osteomyelitis is high, the combination of a positive probe-to-bone test and plain film radiography can be sufficient to diagnose osteomyelitis (likelihood ratio, 14) without the need for other, more expensive radiological studies

Ischemia: 1. Palpation of anterior tibial and posterior tibial pulses (35% sensitive, 100% specific- for wound healing)

2. Lower extremity peripheral artery disease can be assessed noninvasively with the ankle-brachial index. An ankle-brachial index (ABI) less than 0.90 is approximately 98% specific and approximately 85% sensitive for peripheral artery disease. Limitations of ABI- people with diabetes often have medial calcinosis of lower extremity peripheral vessels, resulting in falsely elevated peripheral pressures and a high ankle-brachial index that is insensitive to presence of peripheral artery disease. (RESOURCE LIMITATIONS) In these individuals, the toe-brachial index can be measured, since the digital arteries are less commonly affected by medial calcinosis.35 A toe-brachial index less than 0.70 is consistent with peripheral artery disease.33 Toe pressure of 30 mm Hg or greater, transcutaneous oxygen pressure of 25 mm Hg or greater, and skin perfusion pressure of 40 mm Hg or greater have been associated with higher rates of ulcer healing. The sensitivity and specificity of transcutaneous oxygen pressure for ulcer healing were 0.72 (95% CI, 0.61-0.81) and 0.86 (95% CI, 0.68-0.95), respectively, with a diagnostic OR of 15.81 (95% CI, 3.36-74.45). This is compared with a relatively low progno accuracy for ulcer healing using the ankle-brachial index (with cutoffs of <0.9 and ≥ 1.3), with a sensitivity of 0.48 (95% CI, 0.36-0.61), a specificity of 0.52 (95% CI, 0.42-0.63), and a diagnostic OR of 1.02 (95% CI, 0.40-2.64).

A higher score on the WIfI scale is associated with lower extremity amputation and morbidity and can be used to determine the need for revascularization. WIfI scores of 1, 2, 3, and 4 were associated with 1-year amputation rates of 0%, 8%, 11%, and 38%, respectively

The Wound, Ischemia, and Foot Infection (WIfI) classification system consists of 3 components graded separately from 0 (none) to 3 (severe).

One component may be dominant but the specific combination of scores is used to estimate the risk of limb amputation at 1 year and the need for or benefit of revascularization.[a]

Wound (W)

Grade	Ulcer	Gangrene
0	None	None
1	Small, shallow	None
2	Deep with exposed bone, joint, or tendon	Limited to digits
3	Extensive, deep, and involving forefoot and/or midfoot with or without calcaneal involvement	Extensive and involving forefoot and/or midfoot Full thickness heel necrosis with or without calcaneal involvement

Ischemia (I)

Grade	Ankle-brachial index Ankle systolic pressure	Toe pressure or transcutaneous oximetry
0	≥0.80 >100 mm Hg	≥60 mm Hg
1	0.60-0.79 70-100 mm Hg	40-59 mm Hg
2	0.40-0.59 50-69 mm Hg	30-39 mm Hg
3	≤0.39 <50 mm Hg	<30 mm Hg

Foot infection (fI)

Grade	Clinical manifestation
0	No symptoms or signs of infection
1	Infection indicated by ≥2 of the following: • Local swelling or induration • Erythema 0.5-2.0 cm around ulcer • Local tenderness or pain • Local warmth • Purulent discharge (thick, opaque to white, or sanguineous)
2	Infection as described above with: • Erythema >2 cm around ulcer • Involving structures deeper than skin and subcutaneous tissues (eg, abscess, osteomyelitis, septic arthritis, fasciitis) • No signs of systemic inflammatory response (see below)
3	Infection as described above with ≥2 signs of systemic inflammatory response syndrome: • Temperature >38 °C or <36 °C • Heart rate >90/min • Respiratory rate >20/min or $Paco_2$ <32 mm Hg • White blood cell count >12 000/μL or <4000/μL or 10% immature forms

Management

3 pillars

1. Debridement
2. Off loading
3. Wound dressings

Debridement: Debridement is a standardized approach used to facilitate healing.52 Healing is achieved by eliminating nonviable wound bed and wound edge tissue, including excess callus on the periphery and nonviable dermal tissue, as well as foreign materials and bacterial components. Although guidelines recommend regular debridement, defined as weekly or every other week, randomized clinical trials are lacking

Off loading: The most effective treatment for off-loading a plantar foot ulcer is a knee-high nonremovable off-loading device, either a total contact cast or a knee-high walker rendered nonremovable. Two national surveys of clinicians in the United States and Australia show that the total contact cast was used in only 2% and 15% of patients, respectively, as a primary means

of off-loading. Clinicians frequently cited patient preference as a reason for lack of total contact cast use

Off-loading methods	Description	Outcome/benefit
Knee-high nonremovable off-loading device[51]	Total contact cast or knee-high walker rendered nonremovable	Reduces pressure at the ulcer by 80%-90% compared with a standard shoe[55]; promotes better healing compared with removable devices (relative risk, 1.24; 95% CI, 1.09-1.41 [absolute rates not provided]). First-choice off-loading treatment in international guidelines.[51]
Removable knee-high and ankle-high walkers[51]	Off-loading devices that can be removed by the patient	Reduces pressure effectively but does not promote healing as well as nonremovable walkers or total contact cast. Second-choice off-loading treatment in international guidelines.[51] A study of 20 patients wearing waist-mounted activity monitor and device-mounted monitor reported patients engaged in only 28% of their total daily activity while wearing the protective boot compared with when it was not worn (345 [SD, 219] min vs 874 [SD, 828] min; *P* = .01).[59]

Dressings: Few data are available regarding the optimal wound dressing for diabetic foot ulcers.The selection of a wound dressing for a diabetic foot ulcer should be based on wound characteristics, ie, location, presence and/or degree of inflammation, and amount of exudate The dressing should promote a moist environment conducive to tissue growth and epithelial migration without causing excess maceration. It is important to select dressings that remove excess fluid to prevent further tissue inflammation and damage from prolonged contact with the wound or its periphery. In general, hydrogels are preferred for wounds that produce little exudative drainage, while alginates or hydrofibers are recommended for heavily draining wounds

Table 4. Wound Healing Dressing Types for Diabetic Foot Ulcers[a]

Dressing type	Characteristics and use
Alginates	These dressings form a damp gel on absorption, necessitating a secondary dressing. They are conformable, filling dead spaces and managing moderate to heavy exudate effectively. Suitable for wounds with light to moderate serous drainage.
Antimicrobial dressings	These dressings contain substances such as silver or iodine that inhibit bacterial growth in the wound, making them suitable for infected wounds or those at high risk of infection. However, it is important to note that, as with each of these categories, there is a lack of strong evidence recommending their use despite their widespread application.[52]
Collagens	Derived from bovine, equine, porcine, or ovine (sheep) sources, these products help stimulate wound healing. Available in various forms such as gel, pad, paste, powder, and sheets. Some dissolve entirely while others need removal per the manufacturer's guidelines. A secondary dressing is usually required. Ideal for wounds showing granulation tissue, as they further stimulate its formation.
Film dressings	Thin, transparent dressings that foster a moist environment, promoting healing and enabling wound assessment without removal. Ideal for superficial wounds with minimal exudate.
Foams	These dressings are capable of absorbing moderate quantities of exudate and can be used under compression.
Gauze	Highly permeable dressing material, suitable for wound cleaning, as a cover dressing, and for securing dressings. Gauze is not generally recommended as a primary wound dressing because it can remove healthy granulation tissue during dry dressing changes.
Hydrocolloids	These bacteria-proof dressings facilitate autolytic debridement. They are not appropriate for infected wounds as they may damage fragile skin. Ideal for wounds with insignificant serous drainage.
Hydrogels	These are glycerin and water-based products available as amorphous gels, sheets, or impregnated dressings. They can be antimicrobial, donate moisture to wounds, assist in autolytic debridement, and possibly reduce pain. They require a secondary dressing and are suitable for low-exudate wounds needing additional moisture.

[a] Adapted from Sidawy and Perler.

Treatment of Infected ulcers

Osteomyelitis present- links to AvoMD abx pathways
Osteomyelitis absent- links to AvoMD abx pathways

Although many diabetic foot ulcer infections are superficial, some may require surgical intervention to remove infection in deep soft tissue. I**n the absence of an acute soft tissue infection in forefoot osteomyelitis, antibiotics may be as effective as surgery.**

Treatment of Peripheral arterial disease

DO NOT'S- Pentoxifylline, vasodilator drugs

In patients with chronic limb-threatening ischemia who require revascularization for tissue healing, delayed revascularization is associated with slower healing. A prospective study of 478 patients identified an improved rate of wound healing among patients undergoing revascularization with shorter time to healing among those who received a referral for revascularization within 56 days compared with those who had a longer time to revascularization (hazard ratio [HR], 1.96; 95% CI, 1.52-2.52; $P < .001$ [absolute rates not provided]).

Revascularization should be offered to most patients with chronic limb-threatening ischemia; however, cost, older age, presence and severity of medical comorbidities, impaired functional status, and shorter life expectancy are important preoperative factors to consider when determining whether revascularization is likely to improve outcomes.