DOI: 10.21088/ijmhs.2347.9981.13126.3

Indian Journal of Medical and Health Sciences
Volume 13 Number 1, January - June 2026

REVIEW ARTICLE

Assessment of Diabetic Foot Ulcers: A Review

Yuvaraj Jayaraman[1], Barath Kumar Singh P.[2], Ravi Kumar Chittoria[3]

HOW TO CITE THIS ARTICLE:

Yuvaraj Jayaraman, Barath Kumar Singh P., Ravi Kumar Chittoria. Assessment of Diabetic Foot Ulcers: A Review. Jr. Med. & Health Sci. 2026; 13(1): 17–28.

ABSTRACT

The purpose of this article is to offer a narrative assessment of the various diabetic foot ulcer assessment methods that are included in the clinical practice recommendations. The initial assessment of diabetic foot ulcers should include a comprehensive history of both diabetes and the ulcer, a clinical examination of the ulcer (including its size, depth, and infection indicators), laboratory tests to manage the patient's diabetes and detect any related infections, imaging tests (plain films followed by magnetic resonance imaging, if necessary) for suspected osteomyelitis, non-invasive techniques to check for peripheral artery disease, and radiological tests (Arterial Doppler, CT Angiogram) and Foot scan for pressure points assessment.

KEYWORDS

• Diabetic foot • Assessment • Foot ulcers

INTRODUCTION

The risk of Diabetes is steeply rising in the Indian Subcontinent for past decades. The Neuropathic changes in the foot are the common problem faced by diabetic patients which increases the risk of development of ulcers. The foot changes vary from simple ulcer to total distortion of foot.[1,2] This narrative review article describes the techniques and armamentarium used in the Diabetic foot assessment.

AUTHOR'S AFFILIATION:

[1] Junior Resident, Department of Plastic Surgery, Arunai Medical College and Hospital, Tiruvannamalai, Tamil Nadu, India.

[2] Assistant Professor, Department of Plastic Surgery, Arunai Medical College and Hospital, Tiruvannamalai, Tamil Nadu, India.

[3] Senior Professor and Associate Dean (Academic), Head of IT Wing and Telemedicine, Department of Plastic Surgery and Telemedicine, JIPMER, Puducherry, India.

CORRESPONDING AUTHOR:

Ravi Kumar Chittoria, Senior Professor and Associate Dean (Academic), Head of IT Wing and Telemedicine, Department of Plastic Surgery and Telemedicine, JIPMER, Puducherry, India.

E-mail: drchittoria@yahoo.com

➢ **Received:** 23-07-2025 ➢ **Accepted:** 22-10-2025

MATERIALS AND METHODS

The resources used for writing this narrative review article are collected from Google scholar, PubMed, Cureus and Internet. We have reviewed 48 articles to write this narrative review.

DISCUSSION

This article aims to provide a narrative evaluation of the several diabetic foot ulcer assessment techniques found in the clinical practice guidelines. Initial evaluation of diabetic foot ulcers should involve a thorough history of diabetes and ulcer, followed by a clinical examination of the ulcer (size, depth, and signs of infection), laboratory tests to control the patient's diabetes and identify any associated infections, imaging tests (plain films followed by magnetic resonance imaging if needed) for suspected osteomyelitis, non-invasive methods

to check for peripheral artery disease, and radiological tests (Arterial Doppler, CT Angiogram).[3,4]

We will discuss the assessment of diabetic foot under following headings:

1. History to be collected
2. Clinical Examination
3. Biochemical assessment
4. Radiological assessment
5. Pedological assessment

History to be collected

The duration of diabetes is an important factor in formation of ulcers. The medications taken and the compliance to the treatment are to be addressed. The common complaints with the diabetic patients were burning, tingling, pin pricking, numbness and electric shock-like sensation. Diabetic neuropathy may lead to change in speed of walking posture, gait and loss of balance and coordination in patients.[5] The history regarding Diabetic neuropathy which is the most important factor for development of ulcers in diabetic patients should be obtained. The neuropathy that follows diabetes is mainly peripheral neuropathy which involves feet and toes.

The history about the occupation of the patient, smoking habits as nicotine may rise the blood sugar levels and smoking increase the risk of peripheral vascular disease. History should also include the occupation, alcohol intake, drug history, associated illness; any co-morbidity (Chronic Kidney disease, Bronchial asthma).[6]

History regarding peripheral vascular disease like claudication pain, rest pain, non-healing ulcers, vascular surgery, and angioplasty should be asked. Poor foot care is also an important factor for development of foot ulcer; hence the general care of foot should also enquired.[7]

Diabetes causes autonomic neuropathy. Ask about autonomic dysfunction like dry feet with heel cracks, syncope, hypotension, resting tachycardia, abdominal fullness, altered bowel pattern, faecal incontinence, straining and incomplete voiding of urine, gustatory and differential sweating, and extreme diaphoresis, visual disturbance to rule out diabetic retinopathy.[8]

Clinical Examination

A thorough assessment of the foot should be conducted in a well-illuminated environment at each consultation, following the patient's removal of shoes and socks, to detect any potential concerns. Inadequate footwear and foot deformities are significant factors that lead to friction, erythema, blisters, calluses, and foot ulceration. Certain individuals do not display neuropathic symptoms or grievances; therefore, in such instances, the paramount action is to conduct a comprehensive examination of the foot and lower extremities. Upon the patient's entry into the room, the examination may commence with an assessment of gait.[9] The photographic documenting of malformation and Video documentation of movements and gait has to be done (Figure 1).

Skin Appearance

People with diabetes are more likely to or only get other skin problems. Some of these are eruptive xanthomatosis, diabetes blisters, necrobiosis lipoidica diabeticorum and Acanthosis nigricans. Look for the colour of the skin on the feet and legs, Web spaces cracks, fractures, dry skin on the feet and legs, neuropathy, and poor circulation. Infections may be able to get in through cracks and

openings. You should also look at the calluses, corns, old wounds that have healed, and surgical scars. These are all signs of hard skin or high-pressure spots. Not taking enough care of the callus on the bottom of the foot, the malleolus, or the bony protrusions can cause infection, bleeding, or sores.[9]

Heloma durum or hard corns, usually show up on the tips of the toes or the bottom of the foot because of bad shoes. Heloma molle, also known as soft corns, form in the space between the toes because of the pressure of the toes next to them. They tend to hold on to water and are more likely to get fungal diseases. Corn that hurts and is sick needs help. If your feet smell bad, it could be because you don't clean them well or have web space fungal diseases. If you lose hair on your legs, it could mean that you have peripheral neuropathy and poor blood flow. You should check for guttering between the metatarsals that is caused by muscle loss.[10]

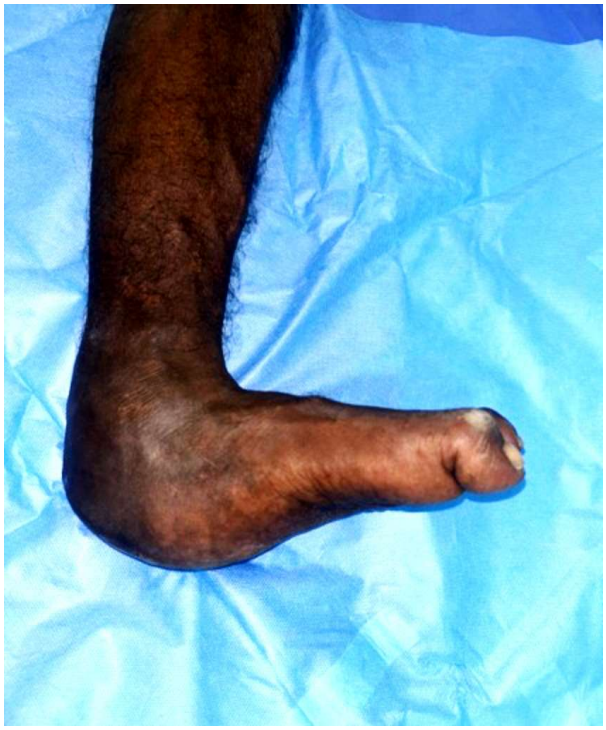

Figure 1: Photographic documentation of deformed foot

Temperature assessment

You can use the back of your hands or more advanced tools, like skin thermometers[11] (Figure 2), Thermal cameras to check the temperature. A change in temperature of at least two degrees from the other foot should be looked at more closely to see if there is cellulitis, an infection, or a problem with the blood flow.[12,13]

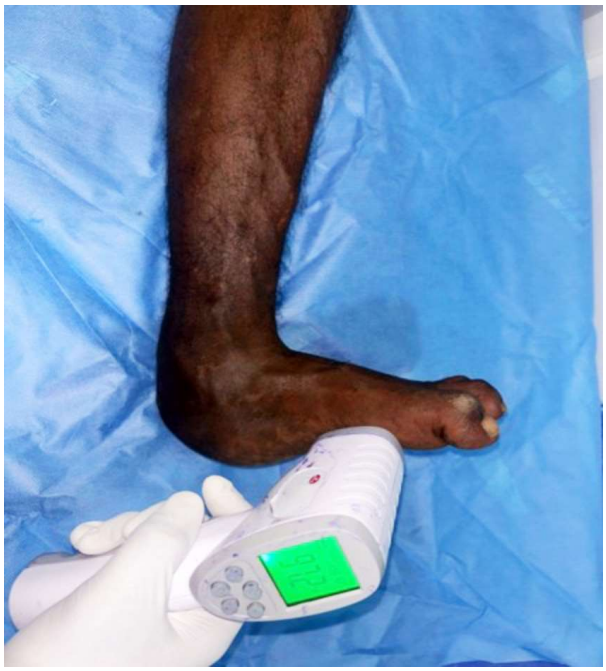

Figure 2: Temperature assesment of foot

Nails and Web Spaces

Individuals with diabetes commonly experience brittle nails, ingrown nails, dystrophic nails, or onychomycosis. Ingrown nails necessitate surgical intervention since they may lead to paronychia or abscess formation. Individuals with diabetes often get inter-digital fungal infections.[14,15] Inadequate foot hygiene practices, attributable to factors such as impaired vision, obesity, aging, and lack of awareness, alongside toe crowding and clawing primarily resulting from motor neuropathy, are significant contributing factors. Therefore, Web gaps and nails must be examined to exclude infections and ensure the patient maintains proper foot care.[16]

Deformities assessment

Deformities and structural alterations in the foot's morphology, including abnormal pressure points and osseous protrusions, are induced by motor and autonomic neuropathy. These anomalies progressively result in skin sores. Peripheral neuropathy induces sensory loss, exacerbating ulceration. Hallux valgus, claw toes, hammer toes, mallet toes, and the crowding or overlapping of toes result from an imbalance between the foot's flexor and extensor muscles.[17] Hammer toes involve plantar flexion of the proximal interphalangeal joints, while mallet toes involve plantar flexion of the distal interphalangeal joints.

The clawing of toes involves dorsiflexion at the tarsometatarsal joints accompanied by plantar flexion at the proximal and distal interphalangeal joints. It is essential to examine for alterations in shape, loss of the foot's arch, flat or high-arched feet, or bony protrusions such as a bunion. Advanced foot abnormalities, including Charcot foot, are generally asymptomatic and may occur in up to 9.8% of patients with diabetes and neuropathy. Repeated micro trauma to an insensate foot results in Charcot foot, a degenerative arthropathy. Chronic Charcot foot must be recognized in a predisposed foot to prevent ulceration and infection.[18]

Vascular Assessment (Pulses)

Peripheral artery disease (PAD) accounts for approximately one-third of foot ulcers and frequently serves as a substantial risk factor for recurring lesions. The patient develops claudication, characterized by leg pain during ambulation that alleviates with rest. In severe cases, discomfort may even occur during rest.[19] During the vascular assessment, the dorsalis pedis and posterior tibial pulses must be palpated and categorized as "present" or "absent."

The two principal arteries that must be palpated are the posterior tibial artery and the dorsalis pedis artery. The dorsalis pedis artery is situated near the base of the navicular bone, adjacent to the extensor hallucis tendon, whereas the posterior tibial artery is positioned somewhat beyond the medial malleolus, equidistant between the medial malleolus and the Achilles tendon. The pulse may be weak, normal, bounding, absent, or imperceptible due to oedema. Additionally, the popliteal artery is palpable posterior to the knee joint when the patient's knee is slightly flexed. Palpation of the femoral artery should be conducted as necessary. The Ankle Brachial Index (ABI) or a vascular Doppler test should be employed for additional assessment if any abnormalities are observed. A vascular specialist may also be advised for these patients.[20]

Hand held Doppler

A hand-held Doppler probe is a small, portable ultrasound device used to assess blood flow. High-frequency sound waves, typically ranging from 8 to 10 MHz, are transmitted into tissues, and the reflected signal is subsequently gathered (Figure 3). Any variation in frequency between the sent and reflected signals signifies that the ultrasonic beam has been reflected off a moving target, specifically moving blood cells. The Doppler machine identifies a frequency alteration and emits this variation as an auditory signal, indicating to the operator that blood flow is occurring. The Doppler signal has various applications. For example, it can be represented on a graph to examine the waveform's contour.[21]

The assessment of systolic pressures in the peripheral arteries of the arm and ankle, a fundamental method for evaluating peripheral vascular health, relies solely on auditory cues. The severity of peripheral vascular disease can be assessed by comparing the systolic pressure at the ankle with that at the centrally situated brachial artery.[22]

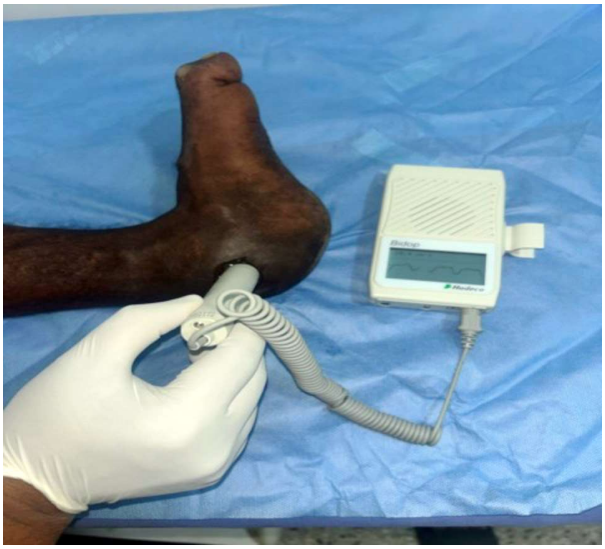

Figure 3: Hand held doppler assessment

ABPI (Ankle brachial Pressure Index)

The Ankle-Brachial Index (ABI) is an expedient and precise method for diagnosing lower limb vascular insufficiency. A standard Doppler ultrasonic probe is employed to assess blood pressure at the ankle (dorsalis pedis or posterior tibial arteries). The ABI is calculated by dividing the ankle systolic pressure by the greater of the two brachial systolic pressures (Figure 4). The standard ratio ranges from 0.9 to 1.4.

Mild peripheral artery disease (PAD) is indicated by an ABI of 0.6 to 0.9, moderate PAD by an ABI of 0.4 to 0.6, and severe PAD or critical limb ischemia (CLI) by an ABI of less than 0.4. A score greater than or equal to 1.4 may also indicate the possibility of PAD,

which could be concealed by atherosclerosis or calcification of the artery wall.[23,24]

The Toe Brachial Index can be computed under these circumstances. It's the proportion of the toe's systolic blood pressure to the arm's systolic blood pressure. Toe blood pressure below 30 mmHg is regarded as critical ischemia, whereas a ratio greater than 0.6 is regarded as normal.[24, 25]

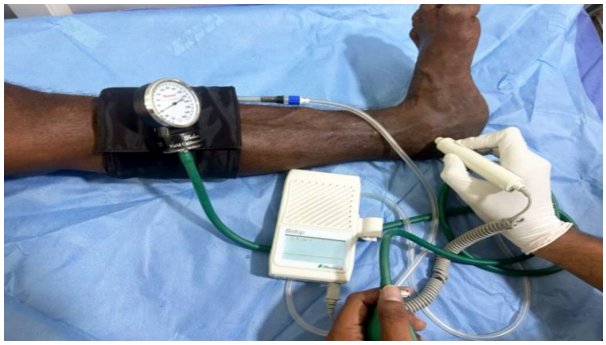

Figure 4: ABPI Measurement

Neuropathy assessment

Assess joint position, vibration, discomfort, touch, and temperature to rule out diabetic neuropathy. Pinpricks measure pain. First test the distal toes, then the proximal ones. Use a cotton wisp to assess tactile sensation. To avoid irritating the skin, gently contact the cotton wisp's tip at precise sight. Patient assessment requires a few fake or simulated strokes.

Foot protective sense is measured with a 10g Semmes-Weinstein monofilament (Figure 5). Pressure is applied to the big toe, metatarsal heads, instep, and heel until a 10 g monofilament buckles to form a C shape that applies 10 g of weight while keeping it perpendicular to the skin. Experiencing contact does not affect the person's protectiveness. Inability to feel at two locations (LOPS) indicates lack of protective feeling. Insensitivity to 10g monofilament increases foot ulcer risk tenfold.[26,27]

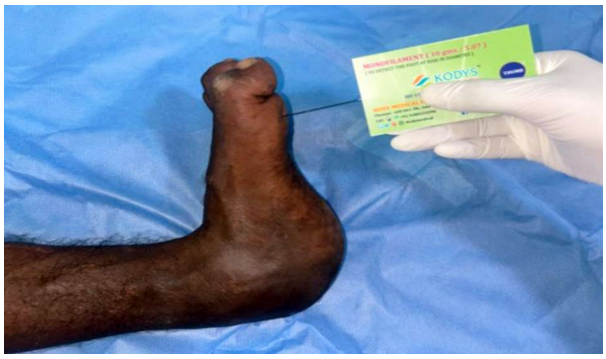

Figure 5: Sensory assessment with Monofilament

Clinicians use the tuning fork to quickly and cheaply examine vibratory feeling. This vibration can be felt using a 128 Hz tuning fork (Figure 6). Set a tuning fork to vibrate on the big toe's metatarsal phalangeal joint. Questions include whether the individual feels the vibration and when it stops. Then it's put on the wrist immediately. If wrist vibration persists, the patient has inadequate vibratory perception. Testing should be bilateral.[28]

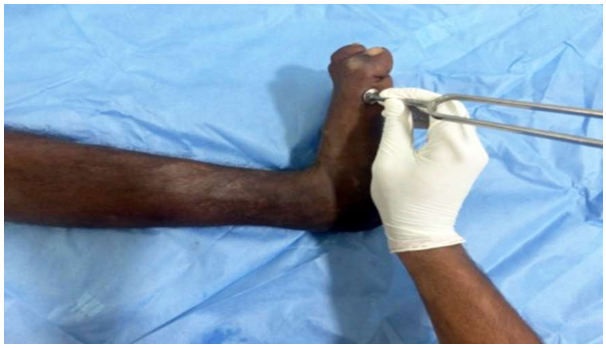

Figure 6: Vibration Sensory assessment with Tuning fork

The biothesiometer, also known as the neurothesiometer, is a straightforward handheld instrument that provides a semi-quantitative evaluation of vibration perception threshold (VPT), which indicates the risk of foot ulceration (Figure 7). A handheld probe is utilized on six fixed locations on the plantar area of the foot, with the vibration threshold being incrementally elevated. The voltage levels at which the patient detects the vibration are recorded. A vibration perception threshold (VPT) of 15-25 volts indicates moderate impairment, whereas a threshold over 25 volts signifies severe impairment. A VPT above 25 V is considered abnormal and is a major predictor of future foot ulcers.[30,31]

Figure 7: Sensory assessment with Advanced Biothesiometer

The great toe's proximal interphalangeal joint is rapidly dorsiflexed and plantarflexed to test for proprioception or joint position. The patient

is then asked about the toe's location. When the patient correctly responds "down," when the toe is plantarflexed, then the proprioception sensation of the joint remains intact.

A knee hammer is employed to evaluate ankle reflexes. The patient may be instructed to squat or recline on a table or couch to evaluate their ankle reflexes. Prior to employing the hammer to impact the Achilles tendon, ensure the tendon is adequately stretched to a neutral position. If no reaction occurs initially, the patient may be directed to interlock their fingers and exert a pulling force. The ankle reflexes may then be re-evaluated with reinforcement. An absence of ankle response at rest or following reinforcement is deemed an abnormal result. The lack of ankle reflexes is correlated with a heightened risk of developing foot ulcers.[32]

Wound and ulcer assessment

WAGNER GRADE

The Wagner's classification is mainly based on the depth of the ulcer (Table 1 and Figure 8). This can also assess the presence of osteomyelitis and gangrene. This classification consists of totally six grades from 0-6. In this grade 1-3 ulcers are termed as non-gangrenous ulcers and grade 4&5 ulcers are termed as gangrenous ulcers.[33]

Table 1: Wagner Grade – Diabetic Foot

ULCER Grade	Description
Grade 0	No open lesion or ulcer, but high risk foot, may have deformities or cellulitis
Grade 1	Superficial ulcer (involves only skin or subcutaneous tissue)
Grade 2	Deep ulcer without complications (extending into deep fascia tendons, ligaments, bone, capsule or muscle)
Grade 3	Deep ulcer with complications (abscess, osteomyelitis, or joint sepsis)
Grade 4	Localized Gangrene involving toes or only forefoot
Grade 5	Extensive Gangrene involving mid and hind foot or whole foot

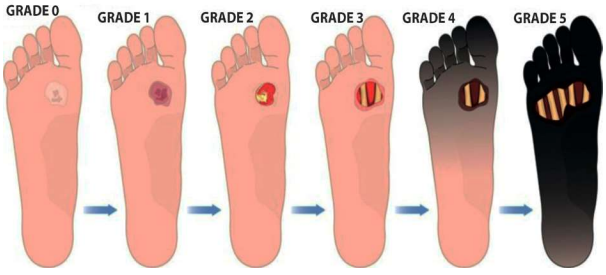

Figure 8: Diabetic Foot – Wagner Grade

Bates-Jenson Wound Assessment Tool

The Bates-Jensen Wound Assessment Tool (BWAT), previously known as the Pressure Sore Status Tool (PSST), is a 15-item objective instrument intended to evaluate wound condition and monitor healing progress. It evaluates the advancement of wound healing. Wounds should be assessed monthly or upon any observed change, with data recorded on the provided Wound Status Continuum to track progress over time.

Fifteen items are evaluated through wound measurement and observations. Thirteen assessed parameters: size, depth, margins, undermining, type and quantity of necrotic tissue, type and quantity of exudate, skin colour surrounding the wound, peripheral tissue oedema and induration, granulation tissue, and epithelialization. Two non-evaluative elements: the site and morphology of the wound. Item-level values vary from 1 to 5 on a modified Likert scale. Each item is evaluated based on the wound characteristic it delineates, with a score of 1 representing the least severe and a score of 5 signifying the most severe. The 13 assessed items get a cumulative maximum score of 65. A higher overall score signifies a more severe wound condition.[34]

Biochemical Assessment

HbA1C

Glycosylated haemoglobin, also known as haemoglobin A1c (HbA1c), is a measure of average plasma glucose over the previous eight to 12 weeks, The worse the glycaemic control, the greater the HbA1c value.[35]

- HbA1c below 5.7%: Normal.
- HbA1c between 5.7% and 6.4%: Prediabetes.
- HbA1c of 6.5% or higher: Diabetes

It is advised to use a HbA1c of 6.5% as the cut off point for diabetes diagnosis. A glucose test result of less than 6.5% does not rule out diabetes. There are no additional preparations needed, such as fasting, and it can be done at any time of day. Many studies in recent times shows there is close relationship between glycated haemoglobin and development of diabetic foot ulcers. The increase in blood levels of this HbA1C may aggravate the lower limb vascular lesions and neuropathy which aids in development of DFU. Also they cause increase in expressions of inflammatory factors and

inhibition of autophagy proteins which also involved in development of DFU. The Diabetic neuropathy, which is caused by nerve damage, especially in the feet and legs, can result from elevated blood sugar levels. This condition can cause numbness and loss of sensation in legs and feet.[35]

Because of this, people could not be aware of tiny cuts or injuries, potentially leading to delayed treatment and worsening of the wound. Long-term hyperglycemia in diabetics can narrow or block peripheral blood vessel lumens, causing vascular endothelial cell damage, red blood cell aggregation, platelet adhesion, and micro vascular embolism, and eventually acral ulcers.

Lipid metabolism disorders change the characteristics tubes and blood, causing fibrin to increase, red blood cells to aggregate, platelets to adhere, and adherent thrombosis to form, causing acral ischemia and hypoxia and ulcer formation. Cytokines secreted from adipose tissue may promote pro-inflammatory states and regulate insulin resistance, sensitivity, and secretion. Micro vascular injury brought on by high blood sugar levels may interfere with the ulcer site's ability to get the nutrients and oxygen required for wound healing.

HbA1c impair WBC function, which would postpone wound healing and raise the patient's chance of developing another infection affects the wound healing. ADA recommended glycemic targets of HbA1C less than 7% in patients without risk of hypoglycemia or a less stringent target of less than 8% in selected patients should be achieved.

CRP- C reactive Protein

In reaction to any inflammation in the body, the liver produces this acute phase protein. In any situation of infection or inflammation, it might be raised and is not sensitive. Numerous acute and chronic inflammatory illnesses, including bacterial, viral, or fungal infections; rheumatism and other inflammatory diseases; cancer; and tissue damage and necrosis, all produce interleukins and some cytokines.

The production of CRP will be triggered by them. As an early line of defence against pathogens, it contributes to innate immunity. High sensitivity CRP (hs-CRP) identifies CRP in the range of 0.5 to 10 mg/L, while traditional CRP measurement recognizes CRP only in the range of 10 to 1,000 mg/L. Normal CRP values in healthy persons range from 0.8 mg/L to 3.0 mg/L. CRP levels between 100 and 500 mg/L are thought to be very predictive of bacterial infection-induced inflammation. Because of its short half-life, the CRP level drops rapidly once inflammation has subsided.[36]

CRP levels can increase 10,000 times in response to a stimulation, from 50 µg/L to over 500 mg. In mild to severe inflammation, CRP can rise 50–100 mg/L in 4–6 hours. Bacterial infection-induced inflammation is predicted by CRP levels between 100 and 500 mg/L. Once inflammation subsides, CRP reduces rapidly due to its short half-life. Metabolic inflammation, which causes arteriosclerosis and type II diabetes, occurs at CRP levels between 2 and 10 mg/L.

Procalcitonin

PCT is a protein precursor of calcitonin hormone, which is synthesized and secreted by C cells in the thyroid gland. Post-inflammatory PCT has been proposed to be regulated by lipopolysaccharides and sepsis-associated cytokines and produced by liver and peripheral blood mononuclear cells. Moreover, it has been shown that PCT is a more precise measure than CRP for the differential diagnosis of bacterial infections. In the diagnosis of DFU ulcer, PCT has been shown to be crucial.

Serum PCT levels, on the other hand, were mainly assessed in the treatment and follow up of infected ulcers; the findings did not distinguish between mild-to-moderate and severe infections of diabetic ulcers. However, it has also been proposed that, the ideal PCT cut-off concentration is 0.25 ng/mL, with sensitivity and specificity of 63.6% and 83.2%. PCT is regarded as a useful biomarker for infection diagnosis, but because of its low sensitivity, it is not very useful for the early diagnosis of diabetic foot ulcers. Further some studies found that there in increase in levels of PCT in DFU patients with cardiovascular disease, suggests that there is increased risk of adverse cardiovascular events in DFU patients with elevated PCT.[37,38]

Radiological assessment

X-RAY

X-rays are the first imaging modality performed because they are easy, cost-effective, less time-consuming than CT or MRI, and can be repeated with less radiation exposure. NICE

guideline strongly recommends an X-ray at the patient's initial examination to confirm OM. Radiographs with acute OM show focal lysis, cortical bone loss and cyst formation, regional osteopenia, periosteal reaction, and trabecular pattern changes. Necrotic bone sequestration, involucrum, and cloaca development characterize chronic OM. For x-ray to show these positive signs of infection, the infection should be at least present for more than 2 weeks. Prior to this x rays are insensitive to diagnose OM. As the sensitivity of X-rays are less, this can be combined with other tests such as probe-to-bone test and inflammatory markers in initial assessment of OM. X-rays are used not only for initial diagnosis of OM but also used in follow up of the patient. Serial of X-rays are taken to assess the effectiveness of the treatment and the progression of the disease. X-rays are also used in Charcot's foot.[39,40]

Doppler

Doppler study is very useful in determining the blood flow in a diabetic foot. Diabetic patients have a higher incidence of developing peripheral arterial disease, so determining the blood flow using Doppler plays a key role in the evaluation of DFU. Studies have shown that there is significantly higher overall diameter of arteries noted in the diabetic population as compared to the control group. Vessel wall thickening is an early symptom of diabetes related changes. One of the important complications of diabetes is micro vascular abnormalities.

Wearable Laser Doppler Flowmetry devices (LDF) are also used nowadays in diabetic foot evaluation mainly for micro vascular abnormalities. Wearable LDF has a unique advantage in rapidly assessing plantar microcirculation in the early stage of diabetic ulceration. Combined with wavelet analysis, it can quantitatively and qualitatively analyse the regulation mechanism of foot microcirculation.[40,41]

CT Bone, Joint and Angiogram

Imaging exams help diabetic foot patients detect Bone and joint abnormalities and characterize vascular abnormalities early. Non-invasive computed tomography angiography (CTA) is frequently employed in clinical practice. These clearly show the anatomical structures and pathological changes of the lower extremity arteries. CTA of the lower extremities tells us the location severity of narrowing, perfusion status, and collaterals. These also helps the surgeon to plan any artery-based flap cover for large non healing ulcers.[42]

MRI

MRI also plays a pivotal role in DFU assessment and is considered as the IOC for diagnosing diabetic foot OM. This can helps to identify osteomyelitis at an earlier stage. In OM, the loss of signal in T_1-weighted images and higher intensity on T_2-weighted images can reveal the pathology as early as 72 hours after infection. However, this bone oedema might be hard to distinguish from non-infectious reasons. MRI detects inflammation before bone changes with 90% sensitivity and 80% specificity. MRI can detect abscesses, tenosynovitis, and joint involvement that these other procedures cannot, providing more accurate bone and soft tissue involvement information.[43]

Bone Scan

Bone scan or scintigraphy along with MRI and WBC scintigraphy also helpful in diagnosing OM in diabetic foot. The principle is that the radioactive material used in bone scan is absorbed in areas of high bone turnover such as infection, repair, or tumour. The three phase scan using Technetium-99m-Medronic acid Bisphosphonate takes images At different point after the nuclear tracer injected such as blood flow, blood pool, and bone uptake which shows areas with active bone turnover. The sensitivity and specificity of OM in diabetic foot are 80-90% and <50%. The less specificity is due to the inability of this scan to differentiate OM from other conditions with increased bone turnover such as gout, bone Mets, fracture, Charcot disease, joint pathology or recent bone surgery. The exact anatomical location and extent of the infection also can't be determined with bone scan. Hence it is often combined with other modalities such as MRI.[44,45]

Pedological Assessment

Foot Scan

Foot scan is also called as the podogram plays a key role in assessing the pressure distribution on the foot (Figure 9). It is very useful in patients with diabetes as the have neuropathy with renders their sensation and increases the risk if ulcers and calluses mainly over the high-pressure points. Podograms are

used in early detection of abnormalities which helps in timely interventions and prevent the complications. Understanding these pressure points helps us towards designing personalised foot wears or insoles, helps the surgeons to plan offloading these pressure points to prevent further damage.[46,47]

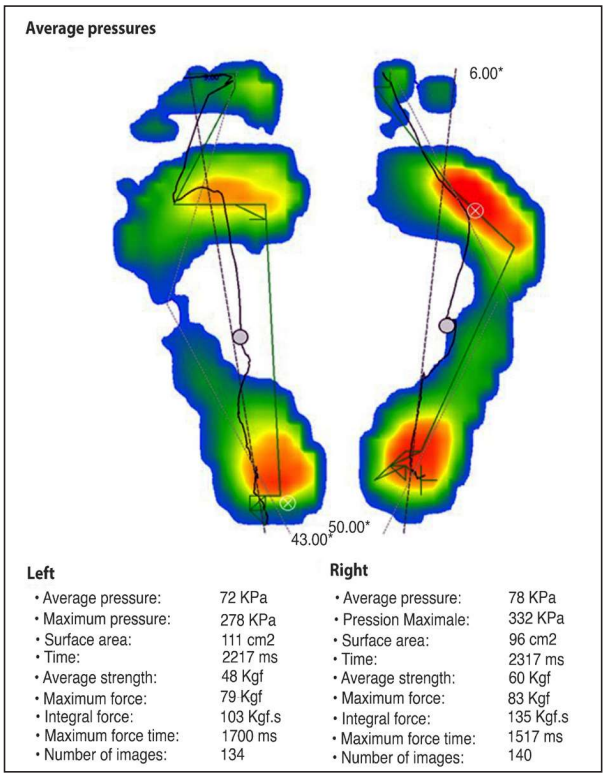

Figure 9: Pedogram Foot Scan

Footwear Examination

The perfect shoe would fit snugly not too tight, but not too loose have a broad toe box, and be tall enough to accommodate the toes, whether or not they had a deformity. The shoe's insole should feel comfortable, and any pressure points or dent should be checked for. Patients should be told to change their shoes or insoles immediately if pressure spots start to show up on the insole. Custom-made shoes are necessary for patients with malformations.[48]

CONCLUSION

As stated earlier Diabetes and Diabetic foot ulcers possess a major threat to health, wellbeing and quality of life of most of the people in Indian subcontinent. With early and proper clinical evaluation, appropriate investigations and standardized assessment tools such as – Wagner's classification, Bate-Jenson wound assessment tool, the depth, severity and the cause of the ulcer can be derived. This helps us in foreseeing the possible complications (infections, amputation, and mortality) and to plan treatment strategies accordingly. Ultimately, by a comprehensive systematic evaluation, risk assessment, prompt intervention, and, crucially, patient education regarding diabetes management and foot care, we can facilitate expedited wound healing, prevent complications, preserve limb function, and enhance the overall quality of life for diabetic patients.

REFERENCES

1. Armstrong D.G., Tan T.W., Boulton AJM, Bus SA. Diabetic Foot Ulcers: A Review. JAMA. 2023 Jul 3; 330(1): 62-75. doi: 10.1001/jama.2023.10578.
2. Monteiro-Soares M., Hamilton E.J., Russell D.A., et al. Classification of foot ulcers in people with diabetes: a systematic review. Diabetes Metab Res Rev. Published online May 2, 2023. doi: 10.1002/dmrr.3645.
3. Swain J., Sahoo A.K., Jadhao P.A., Sravya S.L., Teli B.R. Addressing the Inertia: A Holistic Approach to Diabetic Foot Evaluation. Cureus. 2023 Apr 5;15(4): e37186. doi: 10.7759/cureus.37186.
4. Boulton A.J., Armstrong D.G., Albert S.F., Frykberg R.G., Hellman R, Kirkman M.S., Lavery L.A., Lemaster J.W., Mills J.L. Sr, Mueller M.J., Sheehan P., Wukich D.K.; American Diabetes Association; American Association of Clinical Endocrinologists. Comprehensive foot examination and risk assessment: a report of the task force of the foot care interest group of the American Diabetes Association, with endorsement by the American Association of Clinical Endocrinologists. Diabetes Care. 2008 Aug; 31(8): 1679-85. doi: 10.2337/dc08-9021.
5. Mponponsuo K., Sibbald R.G., Somayaji R. A Comprehensive Review of the Pathogenesis, Diagnosis, and Management of Diabetic Foot Infections. Adv Skin Wound Care. 2021 Nov 1; 34(11): 574-581.
6. Boulton A.J.M., Armstrong DG, Kirsner R.S., *et al*.: Diagnosis and management of diabetic foot complications. American Diabetes Association, Arlington (VA); 2018. 10.2337/db20182-1
7. Al-Rubeaan K., Al Derwish M., Ouizi S., Youssef A.M., Subhani S.N., Ibrahim H.M., Alamri B.N.: Diabetic foot complications and their risk factors from a large retrospective

cohort study. PLoS One. 2015, 10:e0124446. 10.1371/journal.pone.0124446

8. Pop-Busui R., Boulton A.J., Feldman E.L., *et al*.: Diabetic neuropathy: A position statement by the American Diabetes Association. Diabetes Care. 2017, 40: 136-54. 10.2337/dc16-20429.
9. Bristow I.: Non-ulcerative skin pathologies of the diabetic foot. Diabetes Metab Res Rev 24 (Suppl. 1): S84–S89, 2008
10. McGee S.R., Boyko E.J.: Physical examination and chronic lower-extremity ischemia: a critical review. Arch Intern Med 158:1357–1364, 1998
11. Lavery L.A., Higgins K.R., Lanctot D., Constaninides G.P., Zamorano R.G., Athanasiou K.A., Armstrong D.G., Agrawal C.M.: Preventing diabetic foot ulcer recurrence in high-risk patients: the use of temperature monitoring as a self-assessment tool. Diabetes Care 30: 14–20, 2007.
12. Armstrong D.G., Holtz-Neiderer K., Wendel C.S., Mohler M.J., Kimbriel H.R., Lavery L.A.: Skin temperature monitoring reduces the risk for diabetic foot ulceration in high-risk patients. Am J Med 120: 1042–1046, 2007
13. Lavery L.A., Higgins K.R., Lanctot D.R., Constantinides G.P., Zamorano R.G, Armstrong D.G., Athanasiou K.A., Agrawal C.M.: Home monitoring of foot skin temperatures to prevent ulceration. Diabetes Care 27: 2642–2647, 2004
14. Boyko E.J., Ahroni J.H., Cohen V., Nelson K.M., Heagerty P.J.: Prediction of diabetic foot ulcer occurrence using commonly available clinical information: the Seattle Diabetic Foot Study. Diabetes Care 29: 1202–1207, 2006.
15. Peters E.J., Armstrong D.G., Lavery L.A.: Risk factors for recurrent diabetic foot ulcers: site matters. Diabetes Care 30: 2077–2079, 2007.
16. Khan N.A., Rahim S.A., Anand S.S., Simel D.L., Panju A: Does the clinical examination predict lower extremity peripheral arterial disease? JAMA 295: 536–546, 2006.
17. Apelqvist J., Bakker K., van Houtum W.H., Nabuurs-Franssen M.H., Schaper NC: International consensus and practical guidelines on the management and the prevention of the diabetic foot: International Working Group on the Diabetic Foot. Diabete Metab Res Rev 16 (Suppl. 1): S84–S92, 2000.
18. Lavery L.A., Peters E.J., Williams J.R., Murdoch D.P., Hudson A., Lavery D.C: Reevaluating how we classify the diabetic foot: Restructuring the diabetic foot risk classification system of the International Working Group on the Diabetic Foot. Diabetes Care 31: 154–156, 2008.
19. Mills J.L. Sr, Conte M.S., Armstrong D.G., *et al*.; Society for Vascular Surgery Lower Extremity Guidelines Committee. The Society for Vascular Surgery Lower Extremity Threatened Limb Classification System: risk stratification based on wound, ischemia, and foot infection (WIfI). J Vasc Surg. 2014; 59(1): 220–234.
20. van Reijen N.S., Ponchant K., Ubbink D.T., Koelemay M.J.W. The prognostic value of the WIfI classification in patients with chronic limb threatening ischaemia: A systematic review and meta-analysis. Eur J Vasc Endovasc Surg. 2019; 58 (3): 362–371. doi: 10.1016/j.ejvs.2019.03.040.
21. Leoniuk J., Lukasiewicz A., Szorc M., Sackiewicz I., Janica J., Lebkowska U. Doppler ultrasound detection of preclinical changes in foot arteries in early stage of type 2 diabetes. Pol J Radiol. 2014 Aug 29; 79: 283-9.
22. Hu X.X., Xing X.M., Zhang Z.M., Zhang C., Chen L., Huang J.Z., Wang X., Ma X., Geng X. Wearable laser Doppler flowmetry for non-invasive assessment of diabetic foot microcirculation: methodological considerations and clinical implications. J Biomed Opt. 2024 Jun; 29(6): 065001.
23. Roshan R., Chaudhary N., Chouhan U., Huda F., Basu S. Correlation of ankle-wrist pressure index with ankle-brachial pressure index to assess lower limb perfusion in diabetic foot ulcer: A pilot study. J Wound Care. 2024 Jul 2; 33(7): 519-525. doi: 10.12968/jowc.2021.0024.
24. Kashetsky N., Sachdeva M., Lu J.D., Mufti A., Kim P., Bagit A., Sibbald R.G. Diagnostic Accuracy of Ankle-Brachial Pressure Index Compared with Doppler Arterial Waveforms for Detecting Peripheral Arterial Disease: A Systematic Review. Adv Skin Wound Care. 2022 Apr 1; 35(4): 195-201. doi: 10.1097/01.ASW.0000822628.82131.1d.
25. Ghirardini F., Martini R. Current Opinion on Diagnosis of Peripheral Artery Disease in Diabetic Patients. Medicina (Kaunas). 2024 Jul 20; 60(7): 1179. doi: 10.3390/medicina60071179. PMID: 39064610; PMCID: PMC11279131.
26. Aithal, V., Bhat, S. Semmes Weinstein monofilament test for detection of diabetic peripheral neuropathy: sensitivity and specificity. Egypt J Neurol Psychiatry Neurosurg 60, 6 (2024). https://doi.org/10.1186/s41983-023-00785-6
27. Al-Geffari M. Comparison of different screening tests for diagnosis of diabetic peripheral neuropathy in Primary Health Care

setting. Int J Health Sci (Qassim). 2012; 6(2): 127–34.

28. Mythili A., Kumar K.D., Subrahmanyam K.A., Venkateswarlu K., Butchi R.G. A Comparative study of examination scores and quantitative sensory testing in diagnosis of diabetic polyneuropathy. Int J Diabetes Dev Ctries. 2010; 30(1): 43–8.

29. Ruhdorfer A.S., Azaryan M., Kraus J., Grinzinger S., Hitzl W., Ebmer J., *et al*. Selecting a prospective test for early detection of diabetic polyneuropathy. Microsurgery. 2015; 35(7): 512–7.

30. Kelshikar S., Athavale V., Parekh R.A., Ranka M. The Role of a Biothesiometer in Early Detection and Management of Diabetic Neuropathy. Cureus. 2024 Oct 1; 16(10): e70588. doi: 10.7759/cureus.70588. PMID: 39483582; PMCID: PMC11525235.

31. Evaluation of clinical neuropathy in diabetes: use and limitations of biothesiometer. Ramachandran A., Mohan V., McMillan DE, Snehalatha C., Chinnikrishnudu M., Viswanathan M. http://mdrf-eprints.in/386/1/Evaluation_of_clinical_neuropathy_in_diabetes.pdf J Diabetic Assoc India. 1987; 27: 5–9.

32. Kong X., Lesser E.A., Potts F.A., Gozani S.N. Utilization of nerve conduction studies for the diagnosis of polyneuropathy in patients with diabetes: a retrospective analysis of a large patient series. J Diabetes Sci Technol. 2008; 2(2): 268–74.

33. Monteiro-Soares M., Hamilton E.J., Russell D.A., *et al*. Guidelines on the classification of foot ulcers in people with diabetes (IWGDF 2023 update). Diabetes Metab Res Rev. Published online May 14, 2023. doi: 10.1002/dmrr.3648.

34. Gupta S., Srivastava A., Malhotra R., Chadha M., Aggarwal A.N. Wound Assessment Using Bates Jensen Wound Assessment Tool in Acute Musculoskeletal Injury Following Low-Cost Wall-Mounted Negative-Pressure Wound Therapy Application. Indian J Orthop. 2023 Apr 4; 57(6): 948-956.

35. HbA1c variability and diabetic peripheral neuropathy in type 2 diabetic patients. Su J.B., Zhao L.H., Zhang X.L., *et al*. Cardiovasc Diabetol. 2018; 17:47. doi: 10.1186/s12933-018-0693-0.

36. Li X., Wen S., Dong M., Yuan Y., Gong M., Wang C., Yuan X., Jin J., Zhou M., Zhou L. The Metabolic Characteristics of Patients at the Risk for Diabetic Foot Ulcer: A Comparative Study of Diabetic Patients with and without Diabetic Foot. Diabetes Metab Syndr Obes. 2023 Oct 17; 16: 3197-3211. doi: 10.2147/DMSO.S430426.

37. Zhang W.Q., Tang W., Hu S.Q., Fu X.L., Wu H., Shen W.Q., Chen H.L. C-reactive protein and diabetic foot ulcer infections: A meta-analysis. J Tissue Viability. 2022 Aug; 31(3): 537-543. doi: 10.1016/j.jtv.2022.05.001. Epub 2022 May 7. PMID: 35581050.

38. Deng L., Wang G., Ju S. Correlation between inflammatory factors, autophagy protein levels, and infection in granulation tissue of diabetic foot ulcer. Immun Inflamm Dis. 2024 Apr; 12(4): e1233. doi: 10.1002/iid3.1233. PMID: 38577990; PMCID: PMC10996373.

39. Barber A., Webb F. (2016) The use of X-rays for the diagnosis of osteomyelitis in the diabetic foot. The Diabetic Foot Journal 19: 32–6.

40. Malhotra, R., Chan, C.S.Y., & Nather, A. (2014). Osteomyelitis in the diabetic foot. Diabetic Foot & Ankle, 5(1). https://doi.org/10.3402/dfa.v5.24445.

41. Lauri C., Noriega-Álvarez E., Chakravartty R.M., Gheysens O., Glaudemans AWJM, Slart RHJA, Kwee T.C., Lecouvet F., Panagiotidis E., Zhang-Yin J., Martinez JLL, Lipsky B.A., Uccioli L., Signore A. Diagnostic imaging of the diabetic foot: an EANM evidence-based guidance. Eur J Nucl Med Mol Imaging. 2024 Jul; 51(8): 2229-2246. doi: 10.1007/s00259-024-06693-y. Epub 2024 Mar 27.

42. Gao Y., Ma J., Lu T., Qi J. Efficacy and safety of 128 slice CT low-dose scanning technique combined with low-density contrast agent in computed tomography angiography of diabetic foot and lower limb. Am J Transl Res. 2024 Nov 15; 16(11): 7136-7144. doi: 10.62347/VAFX9854.

43. Gariani K., Lebowitz D., Kressmann B., Gariani J., Uçkay I. X-Ray Versus Magnetic Resonance Imaging in Diabetic Foot Osteomyelitis: A Clinical Comparison. Curr Diabetes Rev. 2021; 17(3): 373-377.

44. Pineda C., Espinosa R., Pena A. Radiographic imaging in osteomyelitis: The role of plain radiography, computed tomography, ultrasonography, magnetic resonance imaging, and scintigraphy. Semin Plast Surg. 2009 May; 23(2): 80-9.

45. Lauri C., Noriega-Álvarez E., Chakravartty R.M., Gheysens O., Glaudemans A.W.J.M., Slart R.H.J.A, Kwee T.C., Lecouvet F., Panagiotidis

E., Zhang-Yin J., Martinez J.L.L., Lipsky B.A., Uccioli L., Signore A. Diagnostic imaging of the diabetic foot: An EANM evidence-based guidance. Eur J Nucl Med Mol Imaging. 2024 Jul; 51(8): 2229-2246.

46. Waldecker U. Pedographic classification and ulcer detection in the diabetic foot. Foot Ankle Surg. 2012 Mar; 18(1): 42-9. doi: 10.1016/j.fas.2011.03.004.

47. Lockhart M., Dinneen S.F., O'Keeffe D.T. Plantar pressure measurement in diabetic foot disease: A scoping review. J Diabetes Investig. 2024 Aug; 15(8): 990-999. doi: 10.1111/jdi.14215. Epub 2024 Apr 18.

48. John, Anulekha Mary; Charley, Jessilin K.; Joy, Jibily. Assessment of Footwear among Patients with Diabetes Mellitus: A Cross-Sectional Descriptive Study from South India. Journal of Diabetology 12(1): pp. 41-45, Jan–Mar 2021.