# 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

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It is now 10 years since the last technical review on preventative foot care was published (1), which was followed by an American Diabetes Association (ADA) position statement on preventive foot care in diabetes (2). Many studies have been published proposing a range of tests that might usefully identify patients at risk of foot ulceration, creating confusion among practitioners as to which screening tests should be adopted in clinical practice. A task force was therefore assembled by the ADA to address and concisely summarize recent literature in this area and then recommend what should be included in the comprehensive foot exam for adult patients with diabetes. The committee was cochaired by the immediate past and current chairs of the ADA Foot Care Interest Group (A.J.M.B. and D.G.A.), with other panel members representing primary care, orthopedic and vascular surgery, physical therapy, podiatric medicine and surgery, and the American Association of Clinical Endocrinologists.

## THE PATHWAY TO FOOT ULCERATION

The lifetime risk of a person with diabetes developing a foot ulcer may be as high as 25%, whereas the annual incidence of foot ulcers is ~2% (3–7). Up to 50% of older patients with type 2 diabetes have one or more risk factors for foot ulceration (3,6). A number of component causes, most importantly peripheral neuropathy, interact to complete the causal pathway to foot ulceration (1,3–5). A list of the principal contributory factors that might result in foot ulcer development is provided in Table 1.

The most common triad of causes that interact and ultimately result in ulceration has been identified as neuropathy, deformity, and trauma (5). As identification of those patients at risk of foot problems is the first step in preventing such complications, this report will focus on key components of the foot exam.

## COMPONENTS OF THE FOOT EXAM

### History

While history is a pivotal component of risk assessment, a patient cannot be fully assessed for risk factors for foot ulceration based on history alone; a careful foot exam remains the key component of this process. Key components of the history include previous foot ulceration or amputation. Other important assessments in the history (Table 2) include neuropathic or peripheral vascular symptoms (7,8), impaired vision, or renal replacement therapy. Lastly, tobacco use should be recorded, since cigarette smoking is a risk factor not only for vascular disease but also for neuropathy.

### General inspection

A careful inspection of the feet in a well-lit room should always be carried out after the patient has removed shoes and socks. Because inappropriate footwear and foot deformities are common contributory factors in the development of foot ulceration (1,5), the shoes should be inspected and the question "Are these shoes appropriate for these feet?" should be asked.

**Table 1—*Risk factors for foot ulcers***

- Previous amputation
- Past foot ulcer history
- Peripheral neuropathy
- Foot deformity
- Peripheral vascular disease
- Visual impairment
- Diabetic nephropathy (especially patients on dialysis)
- Poor glycemic control
- Cigarette smoking

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**Table 2—*Essential features of history***

| |
|---|
| Past history |
| • ulceration |
| • amputation |
| • Charcot joint |
| • vascular surgery |
| • angioplasty |
| • cigarette smoking |
| Neuropathic symptoms |
| • positive (e.g., burning or shooting pain, electrical or sharp sensations, etc.) |
| • negative (e.g., numbness, feet feel dead) |
| Vascular symptoms |
| • claudication |
| • rest pain |
| • nonhealing ulcer |
| Other diabetes complications |
| • renal (dialysis, transplant) |
| • retinal (visual impairment) |

Examples of inappropriate shoes include those that are excessively worn or are too small for the person's feet (too narrow, too short, toe box too low), resulting in rubbing, erythema, blister, or callus. Features that should be assessed during foot inspection are outlined in Table 3 and are discussed below.

**Table 3—*Key components of the diabetic foot exam***

| |
|---|
| Inspection |
| Dermatologic |
| • skin status: color, thickness, dryness, cracking |
| • sweating |
| • infection: check between toes for fungal infection |
| • ulceration |
| • calluses/blistering: hemorrhage into callus? |
| Musculoskeletal |
| • deformity, e.g., claw toes, prominent metatarsal heads, Charcot joint (Fig. 1) |
| • muscle wasting (guttering between metatarsals) |
| Neurological assessment |
| 10-g monofilament + 1 of the following 4 |
| • vibration using 128-Hz tuning fork |
| • pinprick sensation |
| • ankle reflexes |
| • VPT |
| Vascular assessment |
| • foot pulses |
| • ABI, if indicated |

**Dermatological assessment.** The dermatological assessment should initially include a global inspection, including interdigitally, for the presence of ulceration or areas of abnormal erythema. The presence of callus (particularly with hemorrhage), nail dystrophy, or paronychia should be recorded (9), with any of these findings prompting referral to a specialist or specialty clinic. Focal or global skin temperature differences between one foot and the other may be predictive of either vascular disease or ulceration and could also prompt referral for specialty foot care (10–13).

**Musculoskeletal assessment.** The musculoskeletal assessment should include evaluation for any gross deformity (14). Rigid deformities are defined as any contractures that cannot easily be manually reduced and are most frequently found in the digits. Common forefoot deformities that are known to increase plantar pressures and are associated with skin breakdown include metatarsal phalangeal joint hyperextension with interphalangeal flexion (claw toe) or distal phalangeal extension (hammer toe) (15–17). (Examples of these deformities are shown in Fig. 1.)

An important and often overlooked or misdiagnosed condition is Charcot arthropathy. This occurs in the neuropathic foot and most often affects the midfoot. This may present as a unilateral red, hot, swollen, flat foot with profound deformity (18–20). A patient with suspected Charcot arthropathy should be immediately referred to a specialist for further assessment and care.

## Neurological assessment

Peripheral neuropathy is the most common component cause in the pathway to diabetic foot ulceration (1,4,5,7). The clinical exam recommended, however, is designed to identify loss of protective sensation (LOPS) rather than early neuropathy. The diagnosis and management of the latter were covered in a 2004 ADA technical review (7). The clinical examination to identify LOPS is simple and requires no expensive equipment.

Five simple clinical tests (Table 3), each with evidence from well-conducted prospective clinical cohort studies, are considered useful in the diagnosis of LOPS in the diabetic foot (1–7). The task force agrees that any of the five tests listed could be used by clinicians to identify LOPS, although ideally two of these should be regularly performed during the screening exam—normally the 10-g monofilament and one other test. One or more abnormal tests would suggest LOPS, while at least two normal tests (and no abnormal test) would rule out LOPS. The last test listed, vibration assessment using a biothesiometer or similar instrument, is widely used in the U.S.; however, identification of the patient with LOPS can easily be carried out without this or other expensive equipment.

**10-g monofilaments.** Monofilaments, sometimes known as Semmes-Weinstein monofilaments, were originally used to diagnose sensory loss in leprosy (21). Many prospective studies have confirmed that loss of pressure sensation using the 10-g monofilament is highly predictive of subsequent ulceration (3,21,22). Screening for sensory loss with the 10-g monofilament is in widespread use across the world, and its efficacy in this regard has been confirmed in a number of trials, including the recent Seattle Diabetic Foot Study (4,21,23,24).

Nylon monofilaments are constructed to buckle when a 10-g force is applied; loss of the ability to detect this pressure at one or more anatomic sites on the plantar surface of the foot has been associated with loss of large-fiber nerve function. It is recommended that four sites (1st, 3rd, and 5th metatarsal heads and plantar surface of distal hallux) be tested on each foot.

The technique for testing pressure perception with the 10-g monofilament is illustrated in Fig. 2; patients should close their eyes while being tested. Caution is necessary when selecting the brand of monofilament to use, as many commercially available monofilaments have been shown to be inaccurate. Single-use disposable monofilaments or those shown to be accurate by the Booth and Young (23) study are recommended. The sensation of pressure using the buckling 10-g monofilament should first be demonstrated to the patient on a proximal site (e.g., upper arm). The sites of the foot may then be examined by asking the patient to respond "yes" or "no" when asked whether the monofilament is being applied to the particular site; the patient should recognize the perception of pressure as well as identify the correct site. Areas of callus should always be avoided when testing for pressure perception.

**128-Hz tuning forks.** The tuning fork is widely used in clinical practice and provides an easy and inexpensive test of vibratory sensation. Vibratory sensation

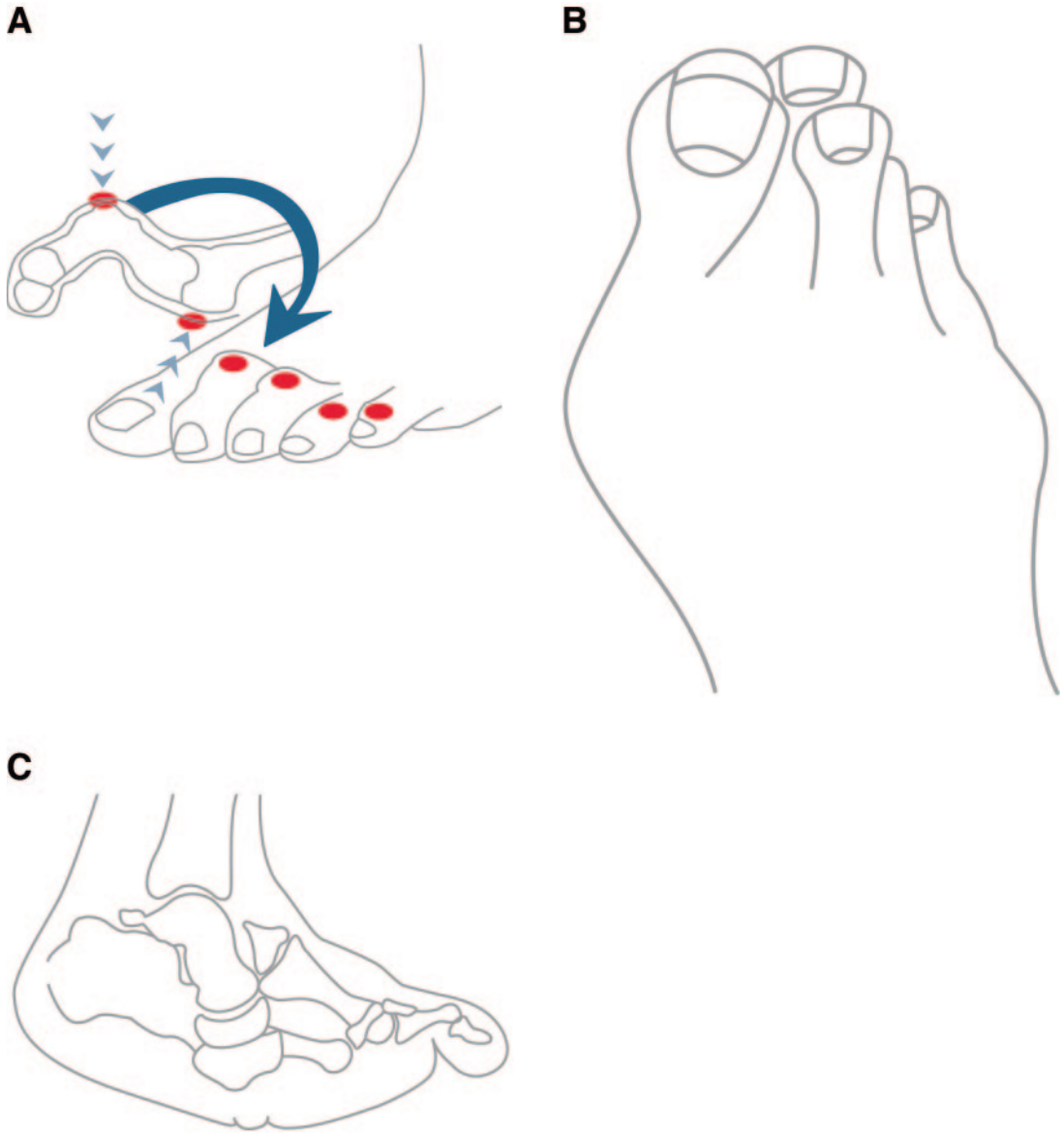


**Figure 1—***Foot deformities. These sites are frequent locations for diabetic foot ulceration.* A*: Claw toe deformity. Note the buckling phenomenon that causes increased pressure on the dorsal hammer digit deformity, as well as on the plantar metatarsal head.* B*: Bunion and overlapping toes. This deformity can lead to pressure ulceration between the digits, on the dorsal or plantar surfaces of displaced digits, and over the medial first metatarsophalangeal joint.* C*: A rocker-bottom deformity secondary to Charcot arthropathy can cause excessive pressure at the plantar midfoot, increasing risk for ulceration at that site.*



should be tested over the tip of the great toe bilaterally. An abnormal response can be defined as when the patient loses vibratory sensation and the examiner still perceives it while holding the fork on the tip of the toe (3,4).

**Pinprick sensation.** Similarly, the inability of a subject to perceive pinprick sensation has been associated with an increased risk of ulceration (4). A disposable pin should be applied just proximal to the toenail on the dorsal surface of the hallux, with just enough pressure to deform the skin. Inability to perceive pinprick over either hallux would be regarded as an abnormal test result.

**Ankle reflexes.** Absence of ankle reflexes has also been associated with increased risk of foot ulceration (4). Ankle reflexes can be tested with the patient either kneeling or resting on a couch/table. The Achilles tendon should be stretched until the ankle is in a neutral position before striking it with the tendon hammer. If a response is initially absent, the patient can be asked to hook fingers together and pull, with the ankle reflexes then retested with reinforcement. Total absence of ankle reflex either at rest or upon reinforcement is regarded as an abnormal result.

**Vibration perception threshold testing.** The biothesiometer (or neurothesiometer) is a simple handheld device that gives semiquantitative assessment of vibration perception threshold (VPT). As for vibration using the 128-Hz tuning fork, vibration perception using the biothesiometer is also tested over the pulp of the hallux. With the patient lying su-

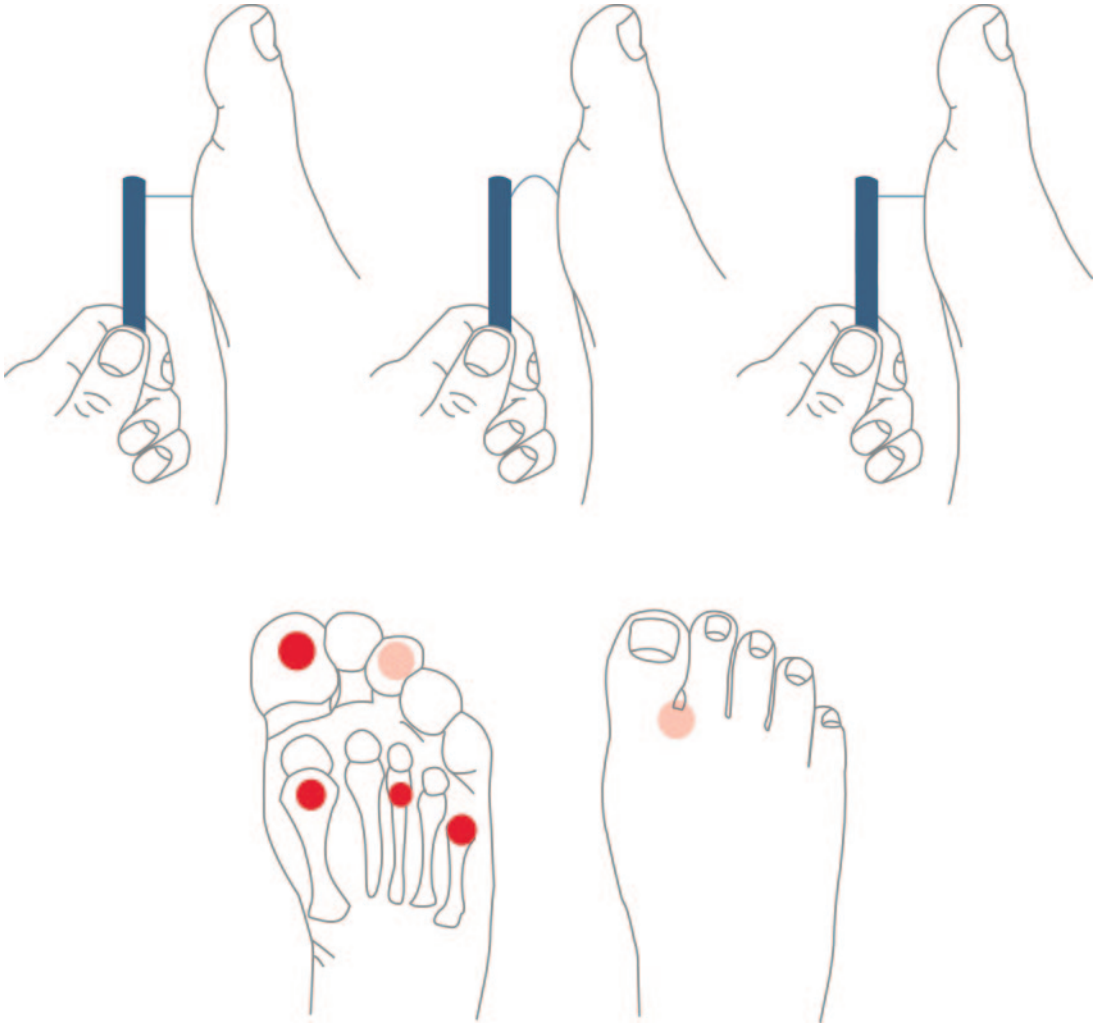

**Figure 2—**Upper panel: *For performance of the 10-g monofilament test, the device is placed perpendicular to the skin, with pressure applied until the monofilament buckles. It should be held in place for ~1 s and then released.* Lower panel: *The monofilament test should be performed at the highlighted sites while the patient's eyes are closed.*

pine, the stylus of the instrument is placed over the dorsal hallux and the amplitude is increased until the patient can detect the vibration; the resulting number is known as the VPT. This process should initially be demonstrated on a proximal site, and then the mean of three readings is taken over each hallux. A VPT >25 V is regarded as abnormal and has been shown to be strongly predictive of subsequent foot ulceration (15,22).

## Vascular assessment

Peripheral arterial disease (PAD) is a component cause in approximately one-third of foot ulcers and is often a significant risk factor associated with recurrent wounds (5,25). Therefore, the assessment of PAD is important in defining overall lower-extremity risk status. Vascular examination should include palpation of the posterior tibial and dorsalis pedis pulses (10,26), which should be characterized as either "present" or "absent" (26).

Diabetic patients with signs or symptoms of vascular disease (Table 2) or absent pulses on screening foot examination should undergo ankle brachial pressure index (ABI) pressure testing and be considered for a possible referral to a vascular specialist. The ABI is a simple and easily reproducible method of diagnosing vascular insufficiency in the lower limbs. Blood pressure at the ankle (dorsalis pedis or posterior tibial arteries) is measured using a standard Doppler ultrasonic probe. This technique is outlined in Fig. 3. The ABI is obtained by dividing the ankle systolic pressure by the higher of the two brachial systolic pressures (8). An ABI >0.9 is normal, <0.8 is associated with claudication, and <0.4 is commonly associated with ischemic rest pain and tissue necrosis.

The ADA Consensus Panel on PAD recommended measurement of ABI in diabetic patients over 50 years of age and consideration of ABI measurement in younger patients with multiple PAD risk factors, repeating normal tests every 5 years (8). ABI may therefore be part of the annual comprehensive foot exam in these patient subgroups. ABI measurements may be misleading in diabetes because the presence of medial calcinosis renders the arteries incompressible and results in falsely elevated or supra-systolic ankle

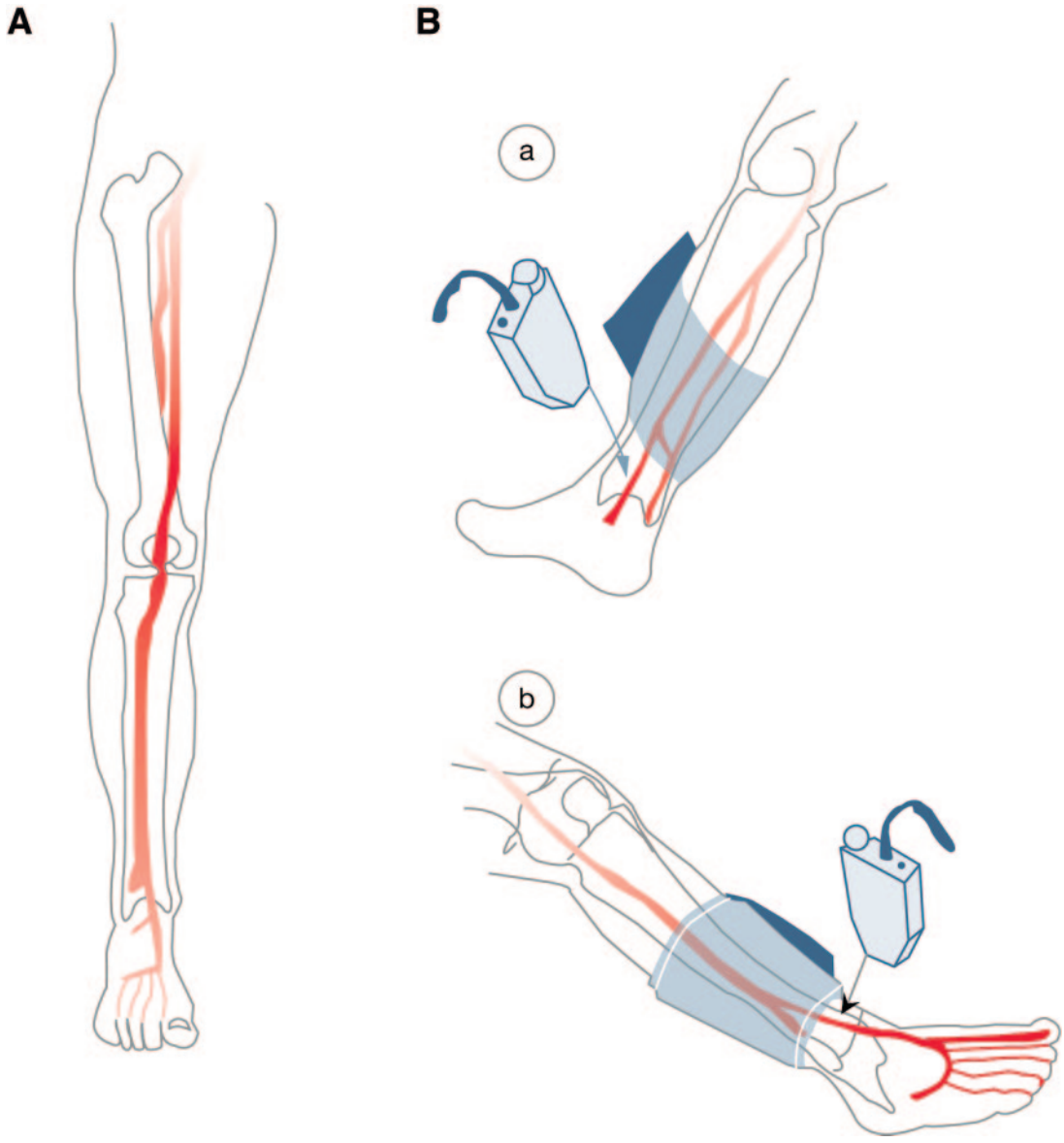


**Figure 3—***Lower-extremity circulation and the ABI test.* A*: Anterior view, right lower limb, normal arterial anatomy.* B*: ABI. Place blood pressure cuff above pulse. Place Doppler probe over arterial pulse;* a*: posterior tibial artery,* b*: dorsalis pedis artery. ABI calculation: Divide ankle systolic blood pressure by brachial artery systolic blood pressure. (ABI >0.9 is normal.) Adapted from Khan et al.,* JAMA *295:536–546, 2006.*

pressures. In the presence of incompressible calf or ankle arteries (ABI >1.3), measurements of digital arterial systolic pressure (toe pressure) or transcutaneous oxygen tension may be performed.

### Risk classification and referral/follow-up

Once the patient has been thoroughly assessed as described above, he or she should be assigned to a foot risk category (Table 4). These categories are designed to direct referral and subsequent therapy by the specialty clinician or team (17,20) and frequency of follow-up by the generalist or specialist. Increased category is associated with an increased risk for ulceration, hospitalization, and amputation (17). Patients in risk category 0 generally do not need referral and should receive general foot care education and undergo comprehensive foot examination annually. Patients in foot risk category 1 may be managed by a generalist or specialist every 3–6 months. Consideration should be given to an initial specialist referral to assess the need for specialized treatment and follow-up. Those in categories 2 and 3 should be referred to a foot care specialist or specialty clinic and seen every 1–3 months.

**CONCLUSIONS** — It cannot be overstated that the complications of the diabetic foot are common, complex, and costly, mandating aggressive and proactive preventative assessments by generalists and specialists. All patients with diabetes must have their feet evaluated at least at yearly intervals for the presence of the predisposing factors for ulceration and amputation (neuropathy, vascular disease, and deformities). This report summarizes a simple protocol for doing so. If abnormalities are present, more frequent evaluation of the diabetic foot is recommended depending on risk category, as described above and in Table 4.

**Table 4—*Risk classification based on the comprehensive foot examination***

| Risk category | Definition | Treatment recommendations | Suggested follow-up |
|---|---|---|---|
| 0 | No LOPS, no PAD, no deformity | • Patient education including advice on appropriate footwear. | Annually (by generalist and/or specialist) |
| 1 | LOPS ± deformity | • Consider prescriptive or accommodative footwear.<br>• Consider prophylactic surgery if deformity is not able to be safely accommodated in shoes. Continue patient education. | Every 3–6 months (by generalist or specialist) |
| 2 | PAD ± LOPS | • Consider prescriptive or accommodative footwear.<br>• Consider vascular consultation for combined follow-up. | Every 2–3 months (by specialist) |
| 3 | History of ulcer or amputation | • Same as category 1.<br>• Consider vascular consultation for combined follow-up if PAD present. | Every 1–2 months (by specialist) |

It is through systematic examination and risk assessment, patient education, and timely referral that we may further reduce the unnecessarily high prevalence of lower-extremity morbidity in this population.

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