

Treatment-based Classification System for Assessment and Care of Diabetic Feet

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Appropriate care of feet of patients with diabetes requires a clear, descriptive classification system that may be used to direct appropriate therapy and possibly predict outcome. Ideally, this system would be used by all participants in a multidisciplinary limb-salvage team. The authors report on a logical, treatment-oriented system that may improve communication, leading to a less complex, more predictable treatment course and, ultimately, an improved result.

Of the approximately 125,000 lower extremity amputations performed each year, it has been estimated that between 56% to 83% are directly attributable to diabetes mellitus.^{1,2} Appropriate care of feet in patients with diabetes requires a clear, descriptive assessment of risk that may be used to direct appropriate therapy and predict outcome.³ This index would ideally be used by all participants in the limb-salvage team. The system should be conceptually simple, yet clinically descriptive.

To make a foot classification system clinically relevant, it must be easy to use, reproducible, and effective to accurately communicate the extent of foot pathology in patients with diabetes mellitus. There are many variables that could be included in such a system, such as level of disease education, patient compliance, family support mechanisms, and comorbidities. However, most of these variables are difficult to measure or categorize. The au-

thors report on a treatment-based clinical index for the diabetic foot that evaluates presence or absence of sensation, deformity, peripheral arterial occlusive disease, previous history of ulceration, infection, and structural deformity.

Risk Factors and Mechanisms of Injury

The pathogenesis of diabetic pedal sequelae is complex. Any one event may have a multifactorial etiology. Many of the more commonly reviewed risk factors for ulceration, infection, and lower extremity amputation are outlined in Table 1. The most common components in the causal pathway to limb loss include peripheral neuropathy, structural deformity, ulceration, infection, and peripheral vascular disease.^{5,6} While all of these factors may play a role in affecting the outcome of the malady, neuropathy coupled with mechanical stress are the prime factors necessary to produce the vast majority of diabetic ulcerations.^{7,8}

Distal symmetric polyneuropathy is perhaps the most common sequela to affect the lower extremity in the patient with diabetes mellitus, affecting up to 58% of those with long-standing disease.⁹ Specifically, the neuropathy affects sensory, motor, and autonomic fibers bilaterally.^{10,11} Neuropathy is an important ingredient necessary for the formation of the diabetic foot ulceration, being present

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Table 1. Potential Risk Factors in the Diabetic Foot⁴

Absent protective sensation
Vascular insufficiency
Foot deformity causing foci of high pressure
Autonomic neuropathy causing fissuring of integument and osseous hyperemia
Limited joint mobility
Obesity
Impaired vision
Poor glucose control causing advanced glycosylation and impaired wound healing
Poor footwear causing or inadequately protecting from tissue breakdown
History of lower extremity amputation
History of foot ulceration

in more than 80% of patients with diabetes with pedal wounds.¹² It is this lack of sensation that, when combined with unaccommodated structural deformity, exposes the patient to undue sudden or repetitive stress, eventual tissue breakdown, subsequent infection, and possible amputation. Distal symmetric polyneuropathy is also an essential ingredient in the pathogenesis of neuropathic osteoarthropathy (Charcot's arthropathy).

One of the most common neuropathic pedal sequelae encountered is the foot ulcer. Appropriate treatment of the ulcer calls for knowledge of its precipitant. The three major extrinsic mechanisms precipitating the neuropathic ulceration are linked by the common thread of mechanical stress.¹³

The first mechanism is defined as direct mechanical disruption of tissue (ie, foreign body) and is commonly seen on the plantar aspect of the foot.

The second mechanism refers to prolonged low pressure over a small radius of curvature (ie, bunion or hammer toe deformity), and therefore generally causes wounds over the medial, lateral, and dorsal prominences of the forefoot.^{14, 15}

The final mechanism involves prolonged repetitive moderate stress. It is this third mechanism that is the most common etiology of the plantar neurotrophic ulceration.¹⁶⁻¹⁸ Wounds caused by the first and third mechanisms listed above are those that respond best to contact casting or other non-weightbearing modalities. Wounds secondary to the second mechanism are generally in nonweight-bearing areas and will therefore respond well to removal of the offending mechanism (ie, immobilization and subsequent shoe accommodation).

Classification Systems

Birke and Sims¹⁹

Modified from Reed's foot risk index, this system is designed as an initial screening tool for nonacute

conditions. It is divided into four categories (0-3). Category zero is defined as protective sensation intact. Category one indicates loss of protective sensation. Patients in category two show a loss of protective sensation with high pressure on the plantar aspect or poor vascularity. Category three includes those with a history of ulcer or neuropathic fracture with major deformity.

This system is easy to use. The authors also make logical shoe recommendations based on foot risk. This classification system does not, however, include infection. In addition, it does not allow for vascular insufficiency to coexist with a previous history of ulceration. As was the intention of the authors, this index is an excellent tool for screening, but may not be as valuable for active or acute conditions, such as open ulceration or acute neuropathic osteoarthropathy.

Enna et al^{20, 21}

In 1976, Enna et al described four categories of non-ulcerated insensitive feet. The first category included subjects lacking only sensation on the plantar aspect. The second category included those suffering from a loss of sensation and "deficiency of the subcutaneous soft tissue." The third category is defined as loss of plantar protective threshold, deficiency of plantar soft tissue, and gross deformity. The fourth category includes the deformed, rigid, short foot secondary to distal osseous disintegration or ablative surgery. Based on these categories, recommendations were made as to appropriate shoe accommodation.

Stess and Hetherington²²

This system divides patients into three categories. The first includes the patient with lack of protective threshold, but with no ulcer and no active bony destruction. The second category includes patients in whom "active bone destruction" is occurring. The third category comprises ulcerated patients with or without bony deformity. Ulcers in this system are subdivided as fundamental or complicated. This classification system does not address vascular insufficiency, nor does it take into account presence or absence of infection.

Ulbrecht et al²³

This risk assessment system, designed to assist in predicting probability of plantar pedal ulceration in the neuropathic patient, is unique in its schematic structure. It incorporates four variables: foot deformity, step loading time, footwear cushioning, and activity level. By plotting the various factors

on a graph, an assessment is made as to the potential foot-risk level. This innovative format provides an excellent framework for forming a logical, organized, treatment-oriented thought process. However, the format used in this system is too subjective to be reproducible on a wide level. Additionally, the present scheme does not include vascular status or infection in its assessment.

Treatment-based Diabetic Foot Index

Objectives of treatment in the following classification system are to convert patients to the lowest possible category. Prior to reviewing the index, three major objective determinants of foot risk, vascular insufficiency, protective threshold, and foot deformity, should be reviewed and defined.

The working diagnosis of lower extremity ischemia is made by a combination of clinical signs and symptoms plus noninvasive vascular results. Clinical signs and symptoms may include claudication, rest-pain, absent pulses, atrophic integument, dependent rubor or pallor on elevation, and subcutaneous atrophy ("baked potato toe"). Noninvasive values include transcutaneous oxygen measurements of less than 40 mm Hg, ankle-brachial index of less than 0.80 mm Hg, or absolute toe systolic pressure less than 45 mm Hg.^{24, 25} One or more clinical signs coupled with abnormal values on one or more of these tests provides a working diagnosis of lower extremity vascular insufficiency. Patients with this diagnosis should receive a vascular surgery consult for definitive evaluation and possible revascularization.

Impaired sensation is defined by the inability to sense the Semmes-Weinstein 5.07 log (10 g) monofilament wire using the technique described by Birke and Sims²⁶. Additionally, a vibration perception threshold of greater than 25 volts, using the technique described by Young et al²⁷, also indicates impaired perception and increased risk of ulceration.²⁸

Foot deformity is defined as any rigid bony prominence placing the patient at risk for the second or third mechanisms of neuropathic repetitive stress injury listed above. This definition includes bunions, hammer toes, plantar prominent metatarsal heads, rocker-bottom deformities, and other prominences with an abnormally small radius of curvature. If the deformity is present on the plantar aspect, it may be best recorded and quantified using an electronic dynamic pressure measurement device.²⁹ Additionally, dermal thermometry or thermography may play a valuable role in identifying

potentially at-risk sites.³⁰

Diabetic Foot Category 0: Minimal Pathology Present (Table 2). The patient assigned to this category has protective sensation intact, the patient's vascular status is intact, and he or she has no previous history of pedal ulceration. The patient may have a foot deformity present, but his or her limb is protected by pain.³¹ Treatment for the patient includes thorough diabetic patient education, possible shoe accommodations if a deformity exists, and triannual visits to assess neurovascular status, dermal thermometry, and foci of stress.

Diabetic Foot Category 1: Insensate Foot (Table 3). Assignment to risk category 1 implies a diminished or absent protective sensation. The category 1 patient has no history of previous pedal ulceration or neuropathic osteoarthropathy (Charcot's joint). In addition, there is no apparent foot deformity present. Treatment for category 1 is the same as for category 0, plus possible in-shoe accommodation to reduce the magnitude of vertical and shear stress. Patients in category 1 may return every 2 to 3 months for general assessment, palliative care, and dermal thermometry. As peak pressures of the plantar aspect may increase with time under the neuropathic foot, patients in this category should receive yearly updates in dynamic pressure analysis to evaluate trends in plantar stress.³²

Diabetic Foot Category 2: Insensate Foot With Deformity (Table 4). This category includes those neuropathic patients with a clinically apparent foot deformity. These subjects have had no history of neuropathic ulceration or Charcot's arthropathy. Treatment for this category includes those measures instituted in category 1, plus possible consultation of a prescription footwear specialist such as a certified pedorthist or orthotist for possible custom-molded or extra depth shoe accommodation. If shoe accommodation is problematic, prophylactic surgery may be indicated to alleviate foci of stress.

Diabetic Foot Category 3: Demonstrated Pathology (Table 5). This category is identical in most respects to category 2. These patients are generally insensate with deformity. However, foot category 3 patients present with a history of pathology including ulceration and Charcot's arthropathy. Clearly, those with a history of foot ulceration are at higher risk for reulceration than those with no previous history.³³⁻³⁵ Treatment for this category is similar to category 2. These patients, however, may be seen more frequently as needed. Additionally, more aggressive shoe accommodation may be necessary to reduce risk of recurrence of pathology.

Table 2. Diabetic Foot Category 0: Minimal Pathology Present

Patient diagnosed with diabetes mellitus
Sensorium intact (Semmes-Weinstein 5.07 wire detectable or vibratory perception threshold < 25 volts)
Ankle brachial index of > 0.80 mm Hg and toe systolic pressure of > 45 mm Hg
Foot deformity may be present
No history of ulceration

Treatment

Triannual visits to assess neurovascular status, dermal thermometry, and foci of stress
Possible shoe accommodations
Patient education

Table 4. Diabetic Foot Category 2: Insensate Foot With Deformity

Patient diagnosed with diabetes mellitus
Sensorium absent
Ankle brachial index of > 0.80 mm Hg and toe systolic pressure > 45 mm Hg
No history of neuropathic ulceration
No history of Charcot's joint
Foot deformity present (focus of stress)

Treatment

Same as category 1 including:
Pedorthic or orthotist consultation for possible custom-molded or extra-depth shoe accommodation
Possible prophylactic surgery to alleviate focus of stress

Diabetic Foot Category 4: Insensate Injury.

The two major injuries stemming from injury to the insensate foot, neuropathic ulceration and acute neuropathic osteoarthropathy (Charcot's joint), are subdivided in this foot risk category.

Category 4A: Neuropathic Ulceration (Table 6). This category includes subjects with noninfected neuropathic ulcerations with no evidence of vascular insufficiency. Treatment for this category is the same as for category 3 with two additions. A pressure-reduction program is instituted, as are weekly or biweekly dressing changes and debridement sessions as required.

Category 4B: Acute Charcot's Arthropathy (Table 7). Category 4B incorporates the patient population diagnosed with acute neuropathic osteoarthropathy. The authors classify Charcot's arthropathy into two treatment-oriented phases based on radiographic, dermal thermographic, and clinical

Table 3. Diabetic Foot Category 1: Insensate Foot

Patient diagnosed with diabetes mellitus
Sensorium absent (Semmes-Weinstein 5.07 wire not detectable or vibratory perception threshold > 25 volts)
Ankle brachial index of > 0.80 mm Hg and toe systolic pressure of > 45 mm Hg
No history of ulceration
No history of diabetic neuropathic osteoarthropathy (Charcot's joint)
No foot deformity

Treatment

Same as category 0 including:
Possible shoe accommodation (pedorthic or orthotist consultation)
Dermal thermometric monitoring every 2 to 3 months
Yearly dynamic plantar pressure updates

Table 5. Diabetic Foot Category 3: Demonstrated Pathology

Patient diagnosed with diabetes mellitus
Sensorium absent
Ankle brachial index of > 0.80 mm Hg and toe systolic pressure of > 45 mm Hg
History of neuropathic ulceration
History of Charcot's joint
Foot deformity present (focus of stress)

Treatment

Same as category 2 including:
Pedorthic or orthotist consultation for custom-molded or extra-depth shoe accommodation
Possible prophylactic surgery to alleviate focus of stress
More frequent visits may be indicated for monitoring

signs. Acute neuropathic may roughly correlate radiographically to Eichenholtz's developmental and early coalescent stages and has been described elsewhere.^{36, 37}

Treatment for category 4B includes prompt institution of a nonweightbearing program (ie, total contact casting). If a Meggitt-Wagner grade I ulcer is present, treatment varies only in that more frequent cast changes may be required for inspection and debridement.^{38, 39} Ulcers with deeper involvement may necessitate further debridement and thus are a relative contraindication to total contact casting.

It should be noted that quiescent, or postacute, Charcot's arthropathy roughly correlates radiographically to Eichenholtz's late coalescent and reconstructive phases. Clinically and thermometrically, all signs of the acute process have resolved with the possible exception of mild residual pedal edema, which frequently dissipates slowly over

Table 6. Diabetic Foot Category 4A: Neuropathic Ulceration

Patient diagnosed with diabetes mellitus
Sensorium may or may not be intact
Ankle brachial index of > 0.80 mm Hg and toe systolic pressure of > 45 mm Hg
Foot deformity normally present
Noninfected neuropathic ulceration
No acute diabetic neuropathic osteoarthropathy (Charcot's joint) present

Treatment

Same as category 3 including:
Offweighting program instituted: possible total contact cast
Dressing change program instituted
Debridement program instituted
Dermal thermometric monitoring
Weekly to biweekly visits as needed
Possible prophylactic surgery

Table 8. Diabetic Foot Category 5: Infected Diabetic Foot

Patient diagnosed with diabetes mellitus
Sensorium may or may not be intact
Infected wound
Charcot's joint may be present

Treatment

Same as category 4 including:
Debridement of infected necrotic tissue and bone
Possible hospitalization
Antibiotic therapy
Medical management
Contact casting generally contraindicated until diabetic foot category drops to 4

Table 7. Diabetic Foot Category 4B: Acute Charcot's Joint

Patient diagnosed with diabetes mellitus
Sensorium absent
Ankle brachial index of > 0.80 mm Hg and toe systolic pressure of > 45 mm Hg
Noninfected neuropathic ulceration may be present
Diabetic neuropathic osteoarthropathy (Charcot's joint) present

Treatment

Same as category 3 including:
Offweighting program instituted: possible total contact cast
Weekly to biweekly visits (as per contact casting regimen)
Dermal thermometric and radiographic monitoring
If ulcer is present, treatment same as for category 4A

Table 9. Diabetic Foot Category 6: Dysvascular Foot

Patient diagnosed with diabetes mellitus
Sensorium may or may not be intact
Ankle brachial index of < 0.80 mm Hg or toe systolic pressure of < 45 mm Hg or pedal transcutaneous oxygen tension of < 40 mm Hg
Ulceration may be present

Treatment

Vascular consult, possible revascularization
If infection present, treatment same as for category 5
Vascular consultation concomitant with control of sepsis
Contact casting generally contraindicated

several months following quiescence. These patients are gradually reintroduced to noncasted weightbearing and, following return to prescription shoes, are most appropriately included in category 3.

Diabetic Foot Category 5: Infected Diabetic Foot (Table 8). The category 5 patient may or may not have intact protective sensation. Limb-threatening infections should be debrided and sepsis controlled prior to attempting revascularization even in the most vascularly compromised extremity.³⁹ If vascular compromise is present, a vascular consultation should be ordered concomitantly with prompt debridement of nonviable tissue.

Diabetic Foot Category 6: Dysvascular Foot (Table 9). The category 6 patient may or may not have intact protective sensation. A noninfected ulceration may or may not be present. The patient is, however, vascularly compromised. For this reason, a prompt vascular surgery consultation is in order

followed by possible revascularization. If revascularization is successful, the patient is converted automatically to a corresponding lower category.

Conclusion

Appropriate care of the feet of patients with diabetes requires a clear, descriptive classification system that may be used to direct appropriate therapy and predict outcome. Ideally, such a system would be used by all participants in the limb-salvage team. Clearly, the classification system reviewed calls for further validation through clinical investigation. The authors believe, however, that a logical, treatment-oriented system, used consistently, may improve communication, leading to a less complex, more predictable treatment course and, ultimately, a reduction in diabetes-related lower extremity amputations.

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