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Prevalence of foot pathology and lower extremity complications in a diabetic outpatient clinic

John J. Holewski, DPM; Kathryn M. Moss, DPM; Richard M. Stess, DPM; Peter M. Graf, DPM; Carl Grunfeld, MD, PhD

Rehabilitation Research and Development Service, Special Team for Amputations, Mobility, Prosthetics/orthotics, Podiatry Section, and Metabolism Section, Veterans Affairs Medical Center, San Francisco, CA 94121; and the Department of Medicine, University of California, San Francisco, CA 94143

Abstract—Multiple risk factors interplay in the formation of foot ulceration and/or limb amputation in the diabetic patient. This study defines the prevalence of foot pathology, lower extremity complications, and known risk factors for ulceration in a cross-sectional analysis of 92 diabetic patients in a Veterans Affairs Metabolic Clinic. Sixteen percent of patients had a history of lower extremity complications including pedal ulceration and/or amputation, previously requiring 1480 hospital days of care. Sixty-eight percent of patients had structural pathology in the foot, including: 51 percent callus, 32 percent hammertoes, 8 percent bunions, and 1 percent Charcot foot. Thirty-four percent of patients were insensate, while 25 percent had autonomic neuropathy. Twenty-two percent of patients had atherosclerosis obliterans as defined by an ankle brachial index less than 0.9; 13 percent suffered from intermittent claudication. The following pathologies were significantly more prevalent in diabetic patients with a history of ulceration and/or amputation compared to those patients without ulceration or amputation: hammertoe deformity ($p < .0001$), abnormal cutaneous pressure sensation ($p < .05$), abnormal R-R interval ($p < .05$), intermittent claudication ($p < .05$), and abnormal ankle brachial index ($p < .05$). An important finding was that 41 percent of insensate patients were not aware of their sensory deficit. In addition, two-thirds of the patients with vascular disease had palpable pulses. All patients with diabetes should be entered into a basic foot education program. The high prevalence of lower extremity pathology coupled with the inadequacy of history and physical examination in detecting neuropathy and vascular disease emphasize the need for vigorous screening to determine whether patients are at high risk of ulceration/amputation. These patients should be entered into aggressive prophylactic treatment programs.

Key words: *amputation, cutaneous pressure, diabetic complications, foot pathology, neuropathy, vascular disease.*

INTRODUCTION

Although there is a consensus among physicians on the importance of foot examinations in the care of diabetic patients, in actuality this practice is often neglected in the clinical setting (2). Unfortunately, pathology in the diabetic foot is often ignored until the onset of serious complications (21).

Numerous risk factors have been implicated in the development of ulceration. Peripheral neuropathy is present in patients who have developed foot ulcers, as shown by a variety of tests (6,17,18,20,38). Some researchers suggest that auto-

Address all correspondence and reprint requests to: Kathryn M. Moss, DPM, Rehabilitation Research and Development Service (151P), Veterans Affairs Medical Center, 4150 Clement Street, San Francisco, CA 94121.

nomic neuropathy is a contributing factor to ulcer development (1,11); peripherally, arterio-venous shunting in the foot due to neuropathy has been implicated (7,14,31,33). A correlation between the prevalence of retinopathy and foot ulcers has been postulated (37,38), while other researchers have disputed the role of microvascular disease (23). It is generally accepted that macrovascular disease increases the risk for ulceration (4,12,24). Structural abnormalities within the foot may be responsible for increased pressure and stresses leading to tissue breakdown during stance and gait (6,8,9,32). The purpose of this cross-sectional study was to determine the prevalence of these risk factors and foot pathology in a diabetic outpatient population.

METHODS

Subject characteristics

One hundred male diabetic patients were consecutively approached during the Metabolic/Endocrine outpatient clinic at the Veterans Affairs Medical Center in San Francisco. Patients with severe neurological disorders unrelated to diabetes (such as paraplegia) were excluded, since the physical findings would be affected by the presence of the underlying neurological disease. The study and consent forms were approved by the Committee on Human Research of the University of California at San Francisco. A complete interview and examination was obtained on 92 patients. Six of the 100 patients approached refused to participate, and two patients never returned to complete the examination (one of these patients expired).

The subject population (all male) ranged from 27 to 83 years of age, with a mean of 59.6 years (**Table 1**). The patients were classified as either insulin dependent, non-insulin dependent, or diabetic secondary to pancreatic disease, according to the standards of the National Diabetes Data Group (27). Eighty percent of the patients had type II diabetes mellitus, and slightly more than half of these type II diabetic patients (53 percent) were on insulin. Twenty percent of the patients had type I diabetes mellitus. Duration of diabetes was calculated from the date of diagnosis. The duration of diabetes ranged from 0.1 to 41 years, with a mean of 13.9 years. Percent ideal body weight was determined using the Metropolitan Life Insurance Statistical Table for medium frame category (25). The subjects on the average were slightly obese with a mean percent ideal body weight of 115.2 percent. Although this survey was limited to male veterans, the remaining demographic characteristics were similar to the general diabetic population of this age group.

Historical information

A standardized history was performed using both patient response and data from the charts to determine diabetes complications (symptomatic neuropathy, ulcers, amputations, retinopathy, chronic renal failure), and vascular complications (claudication, myocardial infarction, angina and hypertension). Anginal chest pain was defined as a history of chest pain in patients concurrently taking nitrates or beta or calcium channel blockers. Patients were classified as having intermittent claudication if they experienced calf pain on exertion within three blocks or less. Retinopathy was determined by opthamologic exam. Renal failure was determined by history of dialysis. Information on current and past cigarette and alcohol use was elicited.

Neuropathy

Prior to the physical examination, patients were asked "Do you think you have good sensation or feeling in your feet?" After responding, they were asked if they had symptoms of burning, tingling, or shooting pains in their feet. This information was acquired to determine the number of patients with clinical symptoms of neuropathy as well as to assess patient awareness of their sensory status.

Admissions

Hospital records of patients with a history of ulcer or amputation were examined and tabulated for the number of admissions for lower extremity complications and the number of hospital days.

PHYSICAL EXAMINATION

All physical examinations were performed by two investigators (J.J.H. and/or K.M.M.). Examinations of the lower extremity were done bilaterally;

Table 1.
Subject characteristics.

Age (yrs.):		
	Mean	59.6
	SD	11.5
	Range	27–83
Type D.M.: N(%)		
	I.D.D.M.	16 (18%)
	N.I.D.M.	74 (80%)
	On insulin	39 (42%)
	Diet/Meds	35 (38%)
	Secondary to pancreatic disease	2 (2%)
Duration D.M.: (yrs.)		
	Mean	13.9
	SD	9.6
	Range	.1–41
Ideal Weight: (%)		
	Mean	115.2
	SD	21.1
	Range	80–190

100 patients in metabolic clinic of SFVAMC (a primary care clinic for patients with diabetes) were approached; 94 patients were evaluated.

in patients who had undergone amputation, only the contralateral limb was evaluated.

Structural pathology

The foot was assessed for the presence of callus, digital deformities, bunions and Charcot deformity. A range-of-motion assessment of the ankle was performed (36). With the patient in a prone position, leg fully extended, and foot held in the neutral position (subtalar joint position two-thirds of the way between maximal inversion and eversion), the patient was asked to maximally dorsiflex the foot on the leg (while maintaining position of the subtalar joint). Patients were categorized as either having: 1) a limitation of dorsiflexion which would not allow ten degrees of motion above a right angle to the leg; or, 2) a normal range of motion greater than/or equal to ten degrees of motion above a right angle to the leg.

Neurological

The Achilles deep tendon reflex was tested. Cutaneous pressure sensation was measured using Semmes Weinstein monofilament probes at six plantar sites, including the area under each metatarsal head, and the pulp of the great toe (20). Sensory deficit was defined as cutaneous pressure sensation thresholds greater than 5.07 log 0.1 mg force in at least three of six plantar sites in one extremity (20). The mean cutaneous pressure sensation threshold was determined by averaging threshold values from six sites on the extremity with a history of ulceration, or on the least-sensitive limb in patients without an ulcer history. Presence of autonomic

neuropathy was ascertained by electrocardiogram examination using the ratio of the longest R-R interval during expiration over the shortest during inspiration (34,35) to assess parasympathetic activity which has been shown to correlate with peripheral nerve dysfunction (38).

Vascular

The presence of palpable dorsalis pedis and posterior tibialis pulses were noted. Ankle brachial index (ABI) was determined by measuring the systolic pressures at the right brachial artery and the posterior tibial arteries bilaterally (10,39). The dorsalis pedis artery was evaluated if a pressure could not be measured at the posterior tibial vessels. Patients were classified as having falsely elevated ankle brachial indices secondary to calcification when vessels could not be occluded at a pressure of 200 mm hg or at 50 mm above brachial systolic pressure. The ABI value was determined by selecting the reading from the limb with a history of ulcer, or the limb with the lowest reading in patients with no ulcer history. Arteriosclerosis obliterans was defined as ankle brachial indices less than 0.9 by the criteria of Beach *et al.* (3).

Statistical analysis

Results are expressed as mean ± SD. Chi-square analysis, the Student's two-tailed *t*-test and Mann Whitney U-test were performed using the Crunch Interactive Statistical Package (Crunch Software Corporation, San Francisco, CA, 1986).

RESULTS

Prevalence of lower extremity complications

Fifteen patients (16 percent) had a history of, or active lower extremity complications: nine patients (9 percent) history of ulceration, one patient (1 percent) active ulceration, four patients (4 percent) digital amputations, and two patients (2 percent) had limb amputation (**Table 2**). To date of survey, a total of 54 admissions, comprising 1480 hospital days, had been accrued for managing lower extremity complications in these 15 patients, ranging from 0 to 653 days total per patient. These admissions represent approximately $700,040 ($473/day/bed) for basic bed fees. Additional charges such as radiology, laboratory, surgical, prosthetic, and rehabilitation expenses are not included. In the six patients who had undergone amputation, a total of 15 amputations (either digital, partial foot, or below the knee) had been performed. One patient had multiple progressive bilateral complications requiring eight different amputations over a three-year period.

Table 2.
Prevalence of lower extremity complications.

History of ulceration	9%
Active ulceration	1%
Digital amputation	4%
Limb amputation	2%
Lower extremity complications overall	16%

Past medical histories were reviewed for 94 patients described in Table 1.

Structural pathology

Sixty-eight percent of all patients had structural abnormalities (**Table 3**). Callus formation was present in 51 percent of the patients. Hammertoe deformities were noted in 32 percent of the patients, while 8 percent had bunions. Charcot foot was noted in one patient (1 percent). When patients were evaluated for ankle joint dorsiflexion, 63 percent of the patients had less than 10 degrees of motion.

Neurological

The prevalence of symptomatic neuropathy without a history of ulceration and/or amputation was 32 percent; overall the incidence was 49 percent. Cutaneous pressure sensation studies revealed that 34 percent of the patients were "insensate" (**Table 4**). Seventeen patients without a history of ulceration or amputation (18 percent) were determined to have sensory deficit. Only nine out of seventeen (59 percent) of these patients felt they had poor sensation; the remainder (41 percent) either felt that they had good sensation (29 percent) or were unsure (12 percent). Even two of the insensate patients with ulceration (13 percent) were not aware of the loss of sensation in their feet. Achilles deep tendon reflexes were absent in 76 percent of the subjects.

Table 3.
Prevalence of structural pathology.

Callous formation	51%
Hammertoe deformity	32%
Bunions	8%
Charcot foot	1%
Limited ankle dorsiflexion	63%

Results from physical examination of feet of 94 patients described in Table 1.

Table 4.
Prevalence of neurological and vascular abnormalities.

Sensory deficit	34%
Autonomic neuropathy	25%
Arteriosclerosis obliterans	12%
Nonpalpable pedal pulses	7%

Sensory and vascular findings in 94 patients described in Table 1.

Twenty-five percent of the subjects had autonomic neuropathy as diagnosed by an R-R interval ratio below 1.10 (34,35). The mean R-R interval ratio was 1.20 $\pm$ 0.16.

Vascular

Bilateral palpable pedal pulses were absent in 7 percent of the patients. However, when ankle brachial indices were evaluated in patients, 22 percent of the patients had ankle brachial indices less than 0.9 indicative of atherosclerosis obliterans as defined by Beach (3). One-third of these patients had nonpalpable pulses, while two-thirds had palpable pulses and would have been missed during clinical examination. It should be noted that 10 percent of the patient population had falsely elevated ankle brachial index readings. Twelve patients (13 percent) complained of intermittent claudication. Of these patients: three had an ABI greater than 0.9; eight had an ABI less than/or equal to 0.9; and one had a falsely elevated reading. Of the patients in our study with a history of ulceration/amputation, ankle brachial indices ranged from 0.45 to 1.2, with only two patients with an ABI less than 0.5.

Other factors

The incidence of other medical complications were: hypertension (52 percent), retinopathy (35 percent), myocardial infarction (23 percent), and renal failure (1 percent). A positive smoking history was elicited from 67 percent of the patients. Only 24 percent had quit smoking; the remainder (43 percent) smoked currently. The overall mean pack/year smoking history was 23.9 $\pm$ 30.5. Current alcohol usage was reported by only 68 percent of the patients. Ten percent reported frequent alcohol consumption and 22 percent reported moderate alcohol consumption. The prevalence of frequent and moderate alcohol consumption was significantly higher ($p<.001$) when patients were asked about their past history. Twenty-eight percent reported a past history of frequent alcohol use and 40 percent reported a past history of moderate alcohol use.

Relationship of lower extremity pathology to ulceration/amputation

The prevalence of several pathologies were significantly increased in diabetic patients with a history of ulceration/amputation compared to patients without these complications (**Table 5**). As generally acknowledged, the duration of diabetes in patients with a history of ulcer/amputation was significantly increased ($p<.05$ as compared with other diabetic patients).

When the prevalence of abnormal cutaneous pressure sensation was examined, abnormal sensation was significantly higher in the ulcer/amputation group ($p<.05$). An even stronger correlation was found using the mean cutaneous pressure sensation threshold which was significantly higher ($p<.001$) in patients with a history of ulcer/amputation. It should be noted that four patients with a history of ulcer/amputation had normal cutaneous pressure sensation. Three of these four sensate patients had clinically documented digital ischemic ulcers as determined by their location, physical characteristics and appearance of the surrounding skin. Ankle brachial indices of 0.6, 0.62, and 0.65, respectively, confirmed the clinical assessment of decreased blood supply to the foot. The remaining patient had no evidence of vascular disease. In addition to sensory deficit, the prevalence of autonomic neuropathy as determined by abnormal R-R interval was significantly increased ($p<.05$) in patients with a history

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Table 5.
Comparison of prevalence and means in patients with and without lower extremity complications.*

	Diabetic subjects without history of ulcer or amputation	(N**)	Diabetic subjects with history of ulcer or amputation	(N**)	P value
Absent Achilles deep tendon reflex	68 (89%)	76	13 (100%)	13	NS
Abnormal cutaneous pressure sensation	29 (38%)	77	10 (71%)	14 †	<.05
Mean ± SD	4.92 ± .68	77	5.79 ± .73	14	<.001
Abnormal R-R ratio	21 (28%)	75	8 (62%)	13	<.05
Mean ± SD	1.20 ± .17	75	1.12 ± .06	13	<.05***
Hammertoe deformity	18 (23%)	77	11 (85%)	13	<.0001
Ankle dorsiflexion 10 degrees	43 (57%)	76	12 (92%)	13	<.05
Callus formation	38 (49%)	77	8 (62%)	13	NS
Bunion deformity	5 (6%)	77	2 (15%)	13	NS
Abnormal ABI	13 (19%)	70	6 (55%)	11	<.05
Mean ± SD	1.05 ± .22	70	.89 ± .34	11	<.05
Retinopathy	22 (29%)	77	10 (67%)	15	.01

* Results are expressed as mean + SD. Chi-square for dichotomous variables, the Student's *t*-test for independent means for continous variables and Mann-Whitney U-test for continuous variables with unequal variances.

** N <77 or N <15 due to:
Ankle Brachial Index—false elevated values discarded.
R-R Interval—4 patients had cardiac arrythmias.
Limited ankle ROM and Achilles DTR—One patient had a fused ankle joint and 2 were amputees.

*** Unequal variances—Mann-Whitney U-test performed.

† Four patients with an ulcer history were sensate. Three of these patients had documented ischemic ulcerations of the digits.

of ulceration/amputation. The mean R-R interval was decreased in ulcer/amputation patients compared to controls ($p<.05$). Abnormal Achilles tendon reflexes were so common in all of our diabetic patients that no increase could be seen in patients with ulcer/amputation.

The prevalence of hammertoe deformity showed the most significant correlation with ulcer/amputation of all factors studied. Hammertoe deformity was significantly increased ($p<.0001$) in patients with ulcer/amputation, while the prevalence of decreased ankle dorsiflexion was also significantly increased ($p<.05$) in these patients. In contrast, the prevalence of callus and bunion deformity were not significantly increased in patients with ulcer/amputation: however, the overall prevalence of bunions was low.

The presence of vascular disease as determined by ankle brachial indices were significantly increased ($p<.05$) in patients with a history of ulcer/amputation. It should be noted that intermittent claudication, a symptom of vascular disease, was also significantly more prevalent ($p<.05$) in these patients. Since the contribution of microvascular disease to foot complications is difficult to determine, we indirectly assessed microangiopathy by determining the presence of retinopathy. Retinopathy was significantly more prevalent ($p=.01$) in patients with a history of ulcer/amputation.

The following factors were not significantly different between patients with, and without, a history of ulceration/amputation: age, percent ideal body weight, myocardial infarction, hypertension, smoking history, and frequency of alcohol use. An analysis of Charcot foot and renal failure was not done due to their low frequency in our sample.

DISCUSSION

Prior studies have addressed the prevalence of lower extremity complications in the diabetic population by focusing on the number of limb amputations performed annually (19,26). This study includes ulceration in addition to amputation as a significant complication. In many patients, ulceration often progresses to partial foot or limb amputation. In this cross-sectional study, 16 percent of the patients have had a prior history of ulceration and/or some type of lower extremity amputation. The two patients with below-the-knee amputations began with foot ulcers and progressed to limb amputation. Collectively, all patients with lower extremity complications accrued 1,480 hospital days for the care of these complications. These data underscore the significant impact of lower extremity complications on patients who suffer from either foot ulceration or amputation.

Structural deformity is thought to contribute to ulcer formation by increasing pressures on the foot in static stance, and during the contact phase of gait (6,8,9,32). In addition to abnormal plantar pressures on weight bearing, structural deformity can increase lateral and dorsal pressures on the foot within the shoe. In the diabetic patient with neuropathy, these abnormal pressures may go unnoticed, and the normal compensatory mechanisms, i.e., shifting weight or removing the source of pressure, will not be initiated, resulting in tissue damage. In this study, 68 percent of all patients had some type of structural abnormality. Callus formation, hammertoe deformity, bunion deformity, and Charcot foot were noted in decreasing order of prevalence. Only eight percent of patients had bunion deformity, which may reflect the fact that only males were included in the study.

Neither the prevalence of structural deformity nor their relationship to ulceration have been well-documented. In this study, the prevalence of hammertoe deformity was strikingly increased ($p < .0001$) in patients with lower extremity complications. This phenomenon may be explained by looking at the mechanism of hammertoe formation and its contribution to ulcer formation. Hammertoes can develop from an imbalance of the intrinsic muscles in the foot secondary to diabetic neuropathy (18). Contraction of the toes can predispose patients to dorsal and plantar lesions on the digits, within the shoe. Ellenberg has previously suggested from non-quantitative clinical observations that hammertoes can be an important element in the development of plantar forefoot lesions (15). As he has described, the digits are held dorsiflexed at the metatarsal phalangeal joints with flexion at the interphalangeal joints; the metatarsal heads are uncovered, thus exposing them to greater trauma and pressure (15). This vulnerability of the metatarsal regions is further compounded in the diabetic patient by the loss of the normal thickness of the metatarsal pad in this region (16). In contrast, there was no statistically significant increase in the prevalence of callus formation and bunion deformity in patients with a history of ulceration/amputation. One patient had bilateral Charcot feet with a history of bilateral plantar ulceration. Although any of the structural deformities have the potential to increase pressures locally in soft tissue, plantar foot pressures have not yet been directly correlated with these deformities.

Delbridge and associates have demonstrated that there was a significant decrease in the range of motion of the subtalar joint in diabetic patients with ulcers when compared with controls ($p = 0.001$) or with other diabetic patients ($p = 0.004$) (13). This study did not evaluate subtalar joint motion; rather, ankle joint range of motion was assessed. Prior studies give varied and wide ranges of ankle joint dorsiflexion measured non-weightbearing (5,22,29). Approximately 10 degrees of dorsiflexion has been estimated to be the minimum amount of motion required at the ankle during stance in normal gait (28,36). In our data, 63 percent of the patients were found to have less than 10 degrees of ankle joint dorsiflexion. Ninety percent of patients with lower extremity complications had a limitation of ankle motion. The prevalence of this limitation of motion

was significantly increased ($p < .05$) in patients with lower extremity complications. As the amount of available ankle joint dorsiflexion decreases, patients may be prone to lift their heel from the ground earlier than normal in the gait cycle, causing premature loading (weightbearing) of the forefoot. This may result in an increased duration of pressure in the plantar forefoot region. Dynamic imbalance of anterior and posterior muscle groups secondary to motor dysfunction in diabetic neuropathy may contribute to the etiology of this decrease in ankle joint range of motion. The correlation of precise angular measurements with pressures could be helpful in documenting the role of decreased dorsiflexion in the development of foot ulcers.

Vascular pathology was evident in our population with 22 percent of the patients showing ankle brachial indices less than 0.9, while 13 percent of the patients had intermittent claudication. Checking pulses alone may not be enough to identify patients with vascular disease, since two-thirds of the patients with abnormal ankle brachial indices had palpable pedal pulses. This data substantiates the need to measure ankle brachial indices or some other measure of vascular inadequacy (i.e., $TcPO_2$) in order to more accurately identify the patients with vascular disease. Likewise, normal resting pulses and indices do not rule out vascular disease; treadmill testing may be required to identify vascular insufficiency in patients complaining of intermittent claudication.

With regards to other risk factors, our findings showed no significant increase in: age, percent ideal body weight, myocardial infarction, hypertension, smoking history, and frequency of alcohol use, in our patients with lower extremity complications. Young *et al.* also found no correlation with age and smoking history in patients with recurrent foot ulceration compared to other diabetic patients with no history of foot ulceration, but did find a correlation with alcohol consumption ($p < .01$) (38). Delbridge *et al.* show a significant increase ($p < .01$) in smoking history in patients with diabetic foot lesions (12). Sosenko *et al.* examined the effects of these factors on neuropathy, which is a prerequisite for the development of foot ulcers (30). Height ($p < .0001$), duration ($p < .01$), age ($p < .05$) and ethanol use ($p < .05$) were significantly associated with the absence of vibratory perception in stepwise multiple logistic regression analysis, but current cigarette smoking and weight did not significantly contribute to their model (30). While there is general agreement that neuropathy is the major risk factor for ulceration (and that peripheral vascular disease contributes to that risk), the role of smoking, alcohol use, age (as opposed to duration of diabetes), and weight, have not been firmly established as predisposing factors.

The significantly higher prevalence of certain foot pathology, neuropathy and vascular complications, i.e., hammertoe deformity, sensory deficit, decreased R-R interval, decreased ABI and retinopathy in patients with lower extremity complications may help identify these patients as "at risk" for ulceration; however, our data cannot yet provide a mathematical model. In this light, our data on neuropathy and macrovascular disease are noteworthy. Using the method described by Holewski *et al.* (20), we found sensory deficit in 34 percent of the clinic patients. As expected from previous studies (6,17,20,38), there was an increased prevalence of loss of sensation in patients with foot ulcers. Unfortunately, adequate neurological testing is not routinely done on patients to identify insensitivity. Relying on subjective symptoms can be misleading, since in this study, 41 percent of the patients without a history of foot ulcers, but with a sensory deficit, were unaware of their decreased sensory status. Only quantitative neurological testing, such as cutaneous pressure sensation, biothesiometry, and thermal sensitivity, can properly identify sensory deficit (3,4,5,7). Likewise, it may be necessary to screen for patients who will develop ulcers secondary to ischemia. Two-thirds of the patients with significant macrovascular disease had palpable pulses. Of the four sensate patients in this study who developed ulcers, three had ankle brachial indices less than 0.7. Although studies have correlated ankle brachial indices with the ability to heal amputation, prospective studies will be necessary to establish at what level diabetic patients are at greater risk of ulceration. Systematic screening of patients for sensory deficit, vascular disease, and structural deformity, may allow the clinician to identify "high risk" patients. Once identified, these patients can be placed into intensive education and prophylactic treatment (i.e., custom footwear or corrective surgery) programs to prevent ulceration.

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