

*Volume No. 9*

*Symposium On Diabetes*

**Diabetes and Foot Problems**

# Introduction

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We, at Magnus Novo Nordisk, are in the forefront of diabetes care by not only providing excellent products but also creating awareness about diabetes. As a leader in diabetes care we feel responsible to join hands with the medical fraternity to help detect diabetes and control it.

Symposium on Diabetes is an effort towards disseminating information about various aspects of diabetes. Eighth in the series was on *Diabetic Nephropathy* wherein evidence based approach of achieving tight glycemic control was put forth for prevention of diabetic nephropathy.

In the current issue we have discussed Diabetic foot, which is one of the most dreaded complication of diabetes. Diabetic foot may be viewed as end point of diabetic neuropathy & peripheral vascular disease and amputation as the end point of diabetic foot.

A strategy that includes prevention, patient and staff education, multidisciplinary treatment of foot ulcers and close monitoring can reduce amputation rates by 49-85%. Therefore, several countries and organizations, such as the World Health Organization and the International Diabetes Federation, have set goals to reduce the rate of amputation by up to 50%.

Yes, most of us would agree that diabetic foot has not received the attention that it deserves. As a vital member of the multidisciplinary team the clinician has a major role to play if the above goal is to be achieved.

Through this quarterly publication *Magnus Novo Nordisk* promise to bring forth more information related to the practical aspects of diabetes. We are hopeful that you will find this series interesting and helpful in your day-to-day clinical practice.

Happy reading!

# Diabetic Foot Problems

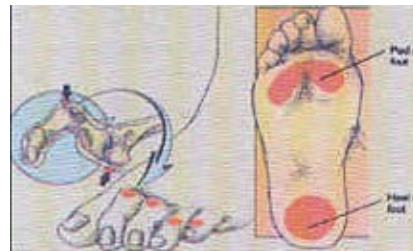
## Introduction

Diabetes mellitus affects more than 120 million people worldwide. As the **“Diabetic Capital of the World”** India, with its largest share of diabetic persons has an uphill task to care for its populace. Spiraling healthcare costs impose tremendous burden on the person and the society. Foot complications are one of the most serious and costly complications of diabetes mellitus. Like most other complications of diabetes, prevention offers hope to the millions who dread the devastating outcome of **Diabetic foot amputation**.

In addition to financial costs, the personal costs to people with diabetes are high and include **pain, decreased independence, lower self-image, disability and premature mortality**.

Among persons with diabetes about 15% will experience a foot ulcer in their lifetime, and about 14-24% of them will require an amputation. In the US, an annual incidence of 2% to 3% and a prevalence of 4% to 10% has been reported. These figures indicate that a large percentage of foot ulcers are chronic.

Half of all amputations in the United States occur in patients with diabetes. Clinical studies show that foot ulcers precede 85% of nontraumatic lower extremity amputations among diabetic patients. Needing a first amputation is a poor prognostic sign in diabetic patients; 28% to 51% of these patients require a second amputation with 5 years. The 5-year mortality rate after lower extremity amputation ranges from 39% to 68%.



Usual location of ulcers in the diabetic foot. Ulceration is particularly likely to occur over the dorsal portion of the toes and on the plantar aspect of the metatarsal heads and the heel.

The vast majority of diabetic foot complication resulting in amputation begin with the formation of skin ulcers.

**Early detection and appropriate treatment of these ulcers may prevent up to 85 percent of amputation<sup>3,4</sup>**. Indeed, one of the disease prevention objectives outlined in the “Healthy People 2000” project of the U.S. Department of Health and Human Services is a 40 percent reduction in the amputation rate for diabetic patients. Physicians have an integral role in ensuring that patients with diabetes receive early and optimal care for skin ulcers.

Unfortunately, several studies<sup>5,6</sup> have found that primary care physicians infrequently perform foot examinations in diabetic patients during routine office visits. The feet of hospitalized diabetics may also be inadequately evaluated.

Involvement of the foot in diabetic can take several forms. If recognized early and treated appropriately its manifestation can be limited in most persons. If neglected or treated inappropriately; it has the potential of resulting in disastrous consequences like gangrene, amputation, overwhelming septicemia and death. Between these two extremes, a variety of pictures of the diabetic foot are described; and the individual manifestation in a given patient depends upon the anatomy of the foot, the stresses associated with locomotion, the severity of diabetes and the average degree of control over blood glucose, and the care taken of the foot by the person with diabetes.

It has been estimated that in developing countries the diabetic foot represents a major cause of morbidity, mortality, and cost of treatment. It is thus necessary that the 'high risk' foot in persons with diabetes be identified and treated appropriately by increasing awareness, education, blood glucose control, and maintaining a constant vigil for minor insults that have the potential to develop into major problems if not detected and treated in time.



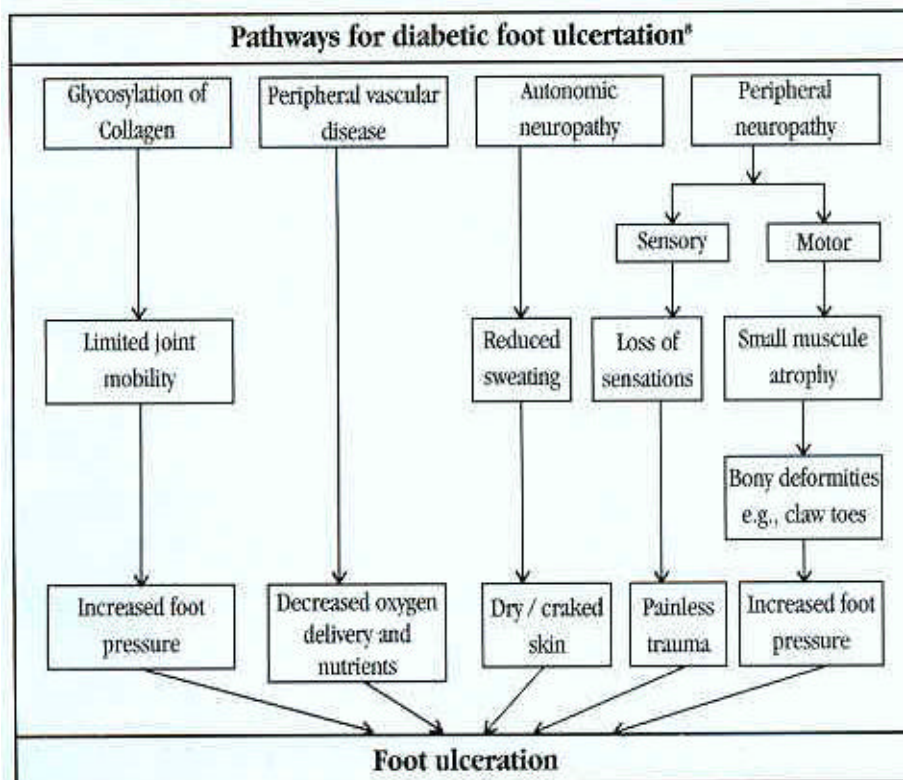
## Pathophysiology

The 'diabetic foot' has traditionally been considered to result from the combination of:

- Peripheral neuropathy – sensory, motor as well as autonomic
- Arterial disease in the leg
- Infection
- Abnormalities of pressure loading on the sole and resulting callus formation
- Defects of the microcirculation, which impair oxygen and nutrient delivery to tissues.
- The role of hyperglycemia in reducing perfusion by producing glycation of basement membrane proteins, and thickening of basement membrane is

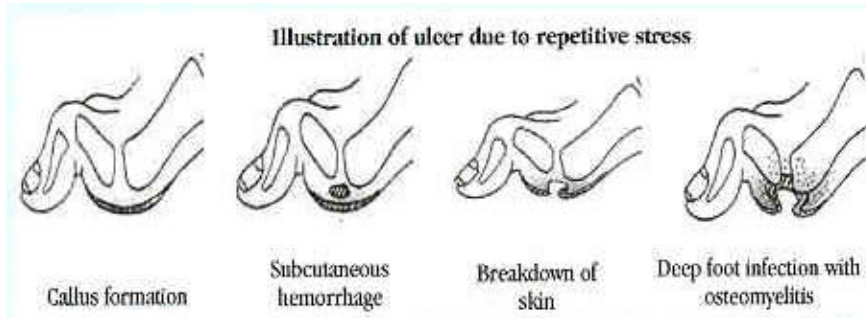
well known. Additional factors that adversely influence microperfusion of the affected foot include hypercoagulability, haemorrhological abnormalities, excessive plaque formation in the large vessels of the lower extremities.

- In the majority of patients diabetic peripheral neuropathy plays a central role. Neuropathy leads to an insensitive and subsequently deformed foot, with possibly, an abnormal walking pattern. In neuropathic patients minor trauma, caused for example by ill-fitting shoes, walking barefoot or an acute injury, can precipitate a chronic ulcer. Loss of sensation, foot deformalities, and limited joint mobility can result in abnormal biomechanical loading of the foot. As a normal response callus is formed, but finally the skin breaks down, frequently precedes by subcutaneous hemorrhage. Whatever the primary cause, the patient continues walking on the insensitive foot, impairing subsequent healing. Peripheral vascular disease, usually in conjunction with minor trauma, may result in a painful, purely ischemic foot ulcer. However, in patients with both neuropathy and ischemia (neuroischemic ulcer), symptoms may be absent despite severe peripheral ischemia.



**Characteristics of diabetic patient at risk of foot ulceration.**

The characteristics of diabetic patients at risk of foot ulceration and the commonly used classification for evaluation of diabetic foot lesions are given in table 1 and table 2 respectively.



**Table 1: Characteristics of patients at risk of developing the diabetic foot syndrome**

- Peripheral neuropathy
  - Somatic
  - Autonomic
- Peripheral vascular disease
- Previous foot ulcers
- Foot deformity e.g. claw toes, Charcot's arthropathy
- Presence of callus
- Blindness or impaired vision
- Nephropathy: especially chronic renal failure
- Elderly: especially if living alone
- Unable to reach foot unaided
- Poor understanding of diabetes
- Inability to feel Semmes – Weinstein nylon monofilament

**Table 2: Wagner's Classification of diabetic foot lesions**

|                |   |
|----------------|---|
| <b>Grade 0</b> | High risk foot, no ulcer  |
| <b>Grade 1</b> | Superficial ulcer, not clinically infected                        |
| <b>Grade 2</b> | Deeper ulcer, often with cellulites, no abscess or bone infection |
| <b>Grade 3</b> | Deep ulcer with bony involvement or abscess                       |
| <b>Grade 4</b> | Localised gangrene (toe, forefoot or heel)                        |
| <b>Grade 5</b> | Gangrene of the whole foot  |

## Screening For Diabetic Foot

All patients must be screened for presence of signs of the high-risk foot at the initial examination at the time of diagnosis. The low risk foot may be followed up annually and the high-risk foot should be followed up as appropriate with referral to a specialist viz. a chiropodist, orthopedic surgeon, and vascular surgeon or rehabilitation expert. Proper foot examination on a regular basis forms an integral part of foot amputation prevention programs.

### History and examination

**History:** Previous ulcer/amputation, previous foot education, social isolation, and poor access to healthcare, bare-foot walking. In a study reported from India, Visvanathan V et. Al, examined 1010 patients for common foot problems such as dry skin, heel fissures and callus formation, and found that foot problems were more common among patients with lower educational status and those who wore footwear for shorter periods of time per day.

**Neuropathy:** Symptoms, such as tingling or pain. Loss of sensation.  
**Vascular status:** Claudication, rest pain, pedal pulses.

**Skin:** Discoloration (rubor) on dependency, colour, temperature, edema, nail pathology (e.g. ingrown nails), wrongly cut nail, ulcer, callus, dryness, cracks, interdigital maceration.

**Bone/Joint:** Deformities (e.g. claw toes, hammer toes) or bony prominences. Loss of mobility (e.g. hallux rigidus)

**Footwear/ stockings:** Assessment of both inside and outside.

Sensory loss due to diabetic polyneuropathy can be assessed using the following techniques:

**Pressure perception:** Semmes- Weinstein monofilaments.

**Vibration perception:** 128 Hz tuning fork.

**Tactile Sensation:** Cotton wool.

**Discrimination:** Pin prick (dorsum of foot, without penetrating the skin)

**Reflexes:** Achilles tendon reflexes

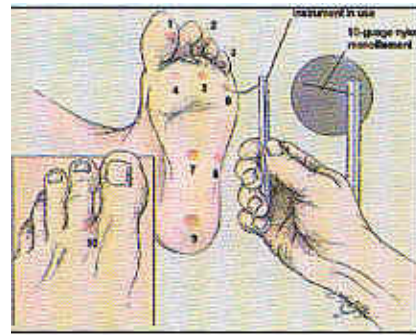
The nylon monofilament test is a simply preformed office test to diagnose patients at risk for ulcer formation due to peripheral sensory neuropathy. The test is abnormal if the patient cannot sense the touch of the monofilament when it is pressed against the foot with just enough pressure to bend the filament.

### **Sensory foot examination:**

Neuropathy can be detected using the 10g (5.07 Semmes-Weinstein) monofilament, tuning fork (128Hz), and/or cotton wisp.

**Semmes - Weinstein monofilament** - Sensory examination should be done in a quiet and relaxed setting. First apply the monofilament on the patient's hands (or elbow, or forehead) so the patients know what to expect.

The patient must not be able to see in and where the examiner applies the filament. The three sites to be tested on both feet are indicated on the tight. Apply the monofilament perpendicular to the skin surface.



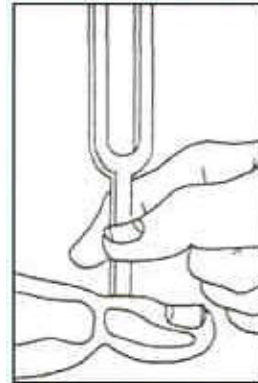
Apply sufficient force to cause the filament to bend or buckle. The total duration of the approach, skin contact, and removal of the filament should be approximately 2 seconds.

Apply the filament along the perimeter of and not on an ulcer site, callus, scar or necrotic. Do not allow the filament to slide the skin or make repetitive contact at the test site. Press the filament to the skin and ask the patient IF they feel the pressure applied (yes/no) and next where they feel the pressure applied (left/right foot).

Nylon monofilament test. There is a risk of ulcer formation if the patient is unable to feel the monofilament when it is pressed against the foot with just enough pressure to bend the filament. The patient is asked to say “yes” each time he or she feels the filament. Failure to feel the filament at four of 10 sites is 97 percent sensitive and 83 percent specific for identifying loss of protective sensation.

Repeat this application twice at the same site, but alternate this with at least one “sham” application, in which no filament is applied (total three questions per site). Protective sensation is present at each site if the patients correctly answers two out of three applications. Protective sensation is absent with two out of three incorrect answers, and the patient is then considered to be at risk of ulceration.

**Tuning fork** - The sensory exam should be done in a quiet and relaxed setting First apply the tuning fork on the patient’s wrists (or elbow, or clavicle) so the patient knows what to expect. The patient must not be able to see if and where the examiner applies the tuning fork.



The tuning fork is applied on a bony part on the dorsal side of the distal phalanx of the first toe. It should be applied perpendicularly with a constant pressure. Repeat this application twice, but alternate this with at least one “sham” application, in which the tuning fork is not vibrating. The test is positive if the patient correctly answered at least two out of three applications, and negative (“at risk for ulceration”) with two out of three incorrect answers. If the patient is unable to sense the vibrations at the big toe, the test is repeated more proximally (malleolus, tibial tuberosities).

**Table 3 lists the clinical tests to be done while evaluating the patient for diabetic foot related problems**

| Neurological and Vascular Function Tests while Screening for Diabetic Foot |   |                              |
|--|---|------------------------------|
| Function   | Clinical Examination  | Investigation                |
| Sensory  | Semmes – Weinstein nylon monofilament Vibration perception threshold test | Biothesiometry               |
| Foot structure and biomechanics  | Foot print  | Pedobarography               |
| Skin   | Erythema, cracks, callus etc.   | Oxygen tension               |
| Motor  | Look for wasting, weakness  | Electrophysiological testing |
| Deformities  | Callus, hammer toe, metatarsal head                                       | X-ray, Foot Pressure         |
| Vascular   | Foot pulses   | Doppler, TcPO2               |

Noninvasive vascular rests include transcutaneous oxygen measurement; the ankle-brachial index (ABI) and the absolute tie systolic pressure. The ABI is a noninvasive test that can be preformed easily in the office using a handheld

Doppler device. A blood pressure cuff is placed on the upper arm and inflated until no brachial pulse is detected by the Doppler device. The cuff is then slowly deflated until a Doppler-detected pulse returns (the systolic pressure). This maneuver is repeated on the leg, with the cuff wrapped around the distal calf and the Doppler device placed over the dorsalis pedis or posterior tibia artery. The ankle systolic pressure divided by the brachial systolic pressure gives the ABI.

The sensitivity and specificity of noninvasive vascular tests are a matter of some controversy. Commonly accepted abnormal values for transcutaneous oxygen measurement, ABI determinations and toe systolic pressure are given in Table 4.

The noninvasive tests have been faulted for underestimating the severity of arterial insufficiency. If lower extremity ischemia is strongly suspected, arteriography or some other imaging study should be performed to confirm or rule out ischemia.

Optimal ulcer healing requires adequate tissue perfusion. Thus, arterial insufficiency should be suspected if an ulcer fails to heal. Vascular surgery consultation and possible revascularization should be considered when clinical signs of ischemia are present in the lower extremity of a diabetic patient and the results of noninvasive vascular tests or imaging studies suggest that the patient has peripheral arterial occlusive disease.

Proper control of concomitant hypertension or hyperlipidemia can help to reduce the risk of peripheral arterial occlusive disease. Smoking cessation is essential for preventing the progression of occlusive disease.

Identifying ischemia in patients with diabetic foot complications can be more difficult than expected, because diabetes masks ischemia. Inactivity and neuropathy may disguise claudication and pain at rest, and arteriovenous shunting may limit pallor and coolness. The foot may be pink and warm and have normal capillary refill but at the same time have insufficient blood flow to heal an ulcer.

An indication of the vascular status of the foot can be derived according to the presence or absence of dorsal-pedal and posterior-tibial pulses. Hair growth on the top of the toes and vigorous capillary refill are signs of good blood flow.

The ankle-brachial index is unreliable in diabetic patients because of medial calcinosis of vessels, so tests that do not rely on vessel-wall compressibility (e.g. Doppler echocardiography, pulse-volume waveforms) may be more suitable. The toe-pressure index is more reliable than the ankle-brachial index because digital vessels are less susceptible to calcinosis. Transcutaneous oxygen pressure measurements are also useful in diabetic patients.

**Table 4: Noninvasive Vascular Tests**

| <b>Test</b>                       | <b>Abnormal value</b>  |
|-----------------------------------|--|
| Transcutaneous oxygen measurement | Less than 40mm Hg  |
| Ankle-brachial index              | Less than 0.80: abnormal<br>Less than 0.45: severe, limb-threatening |
| Absolute toe systolic pressure    | Less than 45mm Hg  |

Plain radiography is warranted in diabetic patients with bony prominences or other clinically apparent abnormalities of the bones of the feet. It can reveal unrecognized fractures and other problems in a high proportion of such patients.

Newer tests available for early detection of the foot at risk include 'pedobarograph' recording, which reveals areas of increased load bearing and helps in designing the proper support for the foot using protective footwear. Measurement of skin temperatures of the soles of the feet using thermography helps in evaluating the state of the microcirculation, and is usually required before the decision to attempt vascular surgery aimed at conservation of the limb can be made.

### **Treatment of non- ulcerative pathology**

In a high risk patient, callus, nail and skin pathology should be treated regularly, preferably by a trained foot-care specialist. If possible, foot deformities should be treated non-surgically (e.g. with an orthosis).

### **Foot ulcer**

A standardized and consistent strategy of evaluating wounds is essential and will guide further therapy. The following items must be addressed:

#### ***The cause of ulcer***

Ill-fitting shoes are the most frequent cause of an ulcer, even in patients with "pure" ischemic ulcers. Therefore, the shoes should be examined meticulously in all patients.

#### ***The type of ulcer***

Most ulcers can be classified as neuropathic, ischemic or neuro-ischemic. This will guide further therapy. Assessment of the vascular tree is essential in the management of a foot ulcer.

### ***The site and depth***

Neuropathic ulcers frequently occur on the plantar surface of the foot, or in areas overlying a bony deformity. Ischemic and neuro-ischemic ulcers are more common on the tips of the toes or the lateral border of the foot.

The depth of an ulcer can be difficult to determine due to the presence of overlying callus or necrosis. Therefore, neuropathic ulcers with callus and necrosis should be debrided as soon as possible. This debridement should not be performed in ischemic or neuro-ischemic ulcers without signs of infection. In neuropathic ulcers the debridement can usually be performed without (general) anesthesia.

### ***Signs of infection***

Infection in a diabetic foot presents a direct threat to the involved limb and should be treated promptly and aggressively. Signs and/or symptoms of infection, such as fever, pain or increased white blood count/ESR, are often absent. But if present, substantial tissue damage or even development of an abscess is likely.

The risk of osteomyelitis should be determined. If it is possible to place a probe down to the bone before initial debridement, there is an increased risk of the presence osteomyelitis.

A superficial infection is usually caused by Gram-positive bacteria. In cases of (possible) deep infections Gram stains and cultures from the deepest tissue involved are advised (no superficial swabs); these infections are usually polymicrobial, involving anaerobes and gram Positive/negative bacteria.

### **Ulcer treatment**

If treatment is based on the following principles healing rates of 80-90% can be attained. The best wound care cannot compensate for continued injury, ischemia or infection. Patients with an ulcer deeper than the subcutis should be treated aggressively and, depending on local resources and infrastructure, hospitalization must be considered.

#### ***Principles of ulcer treatment***

- Relief of pressure.
- Non-weight bearing is essential.
- Limitation of standing and walking, Crutches, etc.

- Mechanical unloading – Total contact casting/other casting techniques
- Temporary footwear – Individually molded insoles.
- Restoration of skin perfusion -Arterial revascularization procedures (results do not differ from non-diabetic patients, but distal bypass-surgery is needed more frequently)
- The benefits of pharmacological treatment to improve perfusion have not yet been established.
- Treat smoking, hypertension and dyslipidemia.

## Treatment of infection

**Superficial ulcer with extensive cellulites** - Debridement with removal of all necrotic tissue and oral antibiotics aimed at Staphylococcus aureus and streptococci-No topical antibiotics

**Deep (limb-threatening) infection** - Surgical drainage as soon as possible (emergency referral) with removal of necrotic or poorly vascularized tissue, including infected bone.

- Revascularization if necessary.
- Broad-spectrum antibiotics intravenously, aimed at Gram-positive and negative microorganisms, including anaerobes.
- Metabolic control and treatment of comorbidity -Optimal diabetes control, if necessary with insulin.
- Treat edema and malnutrition.

**Local wound care** - Frequent wound debridement (with scalpel, e.g. once a week)

- Frequent wound inspection.
- Absorbent, non-adhesive, non-occlusive dressings.
- Footbaths are contra-indicated as they induce maceration of the skin.

### ***Instruction to patient and relatives***

Instruction should be given on appropriate self-care and how to recognize and report signs and symptoms of (worsening) infection, such as fever, changes in local wound conditions or hyperglycemia.

### ***Determining the cause and preventing recurrence***

- Determine cause, as ulceration is a recurrent disease.
- Prevent ulcers on contralateral foot and give heel protection during bed rest.
- Patient must be included in a comprehensive foot-care program with life-long observation.

### **Experimental and future treatments for diabetic foot ulceration**

- Bio-engineered tissues
- Aldose reductase inhibitors
- Vasodilators
- Platelet derived growth factor
- Nerve growth factor
- Hyperbaric oxygen

### **Conclusion**

Foot disease is a common of diabetes that can have tragic consequences.

Careful inspection of the diabetic foot on a regular basis is one of the easiest, least expensive and most effective measures for preventing foot complications. All health care providers of people with diabetes should be able to conduct a simple screening exam of the neurological, vascular, dermatological, and musculoskeletal systems. Awareness and training of healthcare providers in diagnosing and treating diabetic foot disease are paramount and may begin with such simple measures as adding a wall poster or chart reminder to conduct foot examinations in all diabetic patients at every office visit.

Additional expertise in patient education, footwear modifications, nail and callus care, and surgical of the foot may be needed. Providers with interest in the foot may choose to obtain additional training and provide focused management of high-risk foot conditions.

## References

1. American Diabetes Association. Consensus Development Conference on Diabetic Foot Wound Care. *Diabetes Care* 1999; 22(8): 1354-60
2. National Diabetes Data Group. *Diabetes in America*. 2d ed. Bethesda: National Institutes of Health, 1995
3. Nathan DM. The pathophysiology of diabetic complications: how much does the glucose hypothesis explain? *Ann Intern Med* 1996; 124(1 pt 2): 86-9
4. Meigs JB, Singer DE, Sullivan LM, et al. Metabolic control and prevalent cardiovascular disease in non-insulin-dependent diabetes mellitus (NIDDM): the NIDDM patient outcomes research team. *Am J Med* 1997; 102 (1): 38-47
5. Caputo GM, Cavanagh PR, Ulbrecht JS, et al. Assessment and management of foot disease on patients with diabetes. *N Engl J Med* 1994; 331(13): 854-60
6. McMohan MM, Bistran BR. Host defenses and susceptibility to infection in patients with diabetes mellitus. *Infect Dis Clin North Am* 1995; 9(1): 1-7
7. Litzelman DK, Slemenda CW, Langefeld CD, et al. Reduction of lower extremity clinical abnormalities in patients with non-insulin-dependent diabetes mellitus. *Ann Intern Med* 1993; 119(1): 36-41
8. Pendsey S. Preventing the diabetic foot. *NNDU Proceedings* 1997, 55-61.
9. Visvanathan V, Rajsekhar S et al. Routine foot examination: the first step towards prevention of diabetic foot amputation. *Pract Diab Int* 2000; 17(4): 112-114.
10. Armstrong DG, Lavery LA. Diabetic Foot Ulcers: Diagnosis and Classification. *Am Family Physician* March 15, 1998.

## Foot Problems: Expert's Opinion

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### **Dr. Vinod Kumar Gujral, Delhi**

The foot care habits of Indian Diabetics and Doctors need to be improved. There is no excuse for not able to prevent those thousand of amputations. It is not the cost but the awareness that is coming in our way. It has been proved with UKPDS and DCCT that good glycaemic goes a long way in preventing and delaying foot problems in diabetics.

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### **Dr. Sushil Jindal, Bhopal**

Apart from proper foot care, the importance of good glycemic control cannot be overemphasized in prevention of diabetic foot complications. Tight glycemic control retards the development of neuropathy and vasculopathy, the root causes for foot complications. In established causes of diabetic foot it helps in healing and control of infections.

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### **Dr. Jagdish Gotur, Mumbai**

While treating diabetic gangrene is the job of a surgeon, prevention still remains the job of the primary care physician, including the G. P. This involves systemic treatment in the form of meticulous glycemic control, BP control and lowering LDL-cholesterol<100mg%. Foot care necessitates avoidance of injury like use of closed, well fitting, footwear (canvas shoes), trimming of toenails, avoidance of bare foot walking especially outdoors, etc. Talk with the patient about his feet. It is a learning and a rewarding experience.

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### **Dr. Arun Bal, Mumbai**

Diabetes is multisystem disease and foot complication is one of the dreaded complications. However most of the foot problem in Diabetes in India are Neuropathic infection and hence easily preventable and cost effectively treatable. There is need for every detection of neuropathy by using simple method like monofilament. Use of scientifically made footwear, patient education, toe & foot care, early detection of neuropathy, proper footwear will help us to achieve the goal of St. Vincent's declaration of reducing limb amputation by 50%.

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