# A STUDY ON DIABETIC FOOT CLASSIFICATION SYSTEM

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# CERTIFICATE

This is to certify that this dissertation entitled **"A STUDY ON DIABETIC FOOT CLASSIFICATION SYSTEM "** submitted by **Dr. N.GOPI** to The Tamil Nadu Dr.M.G.R. Medical University, Chennai is in partial fulfillment of the requirement for the award of M.S. degree Branch I (General Surgery) and is a bonafide research work carried out by him under direct supervision and guidance.

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# DECLARATION

I, Dr. N.GOPI declare that I carried out this work on **"A STUDY ON DIABETIC FOOT CLASSIFICATION SYSTEM"** at Department of General Surgery, Government Rajaji Hospital during the period of June2005 – June2006. I also declare this bonafide work or a part of this work was not submitted by me or any other for any award, degree, diploma to any university, board either in India or abroad.

This is submitted to the Tamilnadu Dr.M.G.R. Medical University, Chennai in partial fulfillment of the rules and regulation for the M.S. Degree examination in General Surgery.

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# CONTENTS

# INTRODUCTION

**D**iabetes continues to be one of the most common underlying factors associated with lower- extremity amputation in postindustrialized and developing countries. Amputations are perhaps the most feared and well-recognized complication of diabetes by the general public.

For most patients, amputation is a pivotal event that alters their quality and duration of life and strain on heart, when amputated patients uses crutches or artificial limb. Amputations have been associated with an increased risk of reamputation of the same extremity , amputation of the contralateral leg , an elevated mortality rate in the first 3–5 years after amputation, and placement in nursing homes or extended care facilities .

There are several well-accepted predisposing factors that place patients with diabetes at high risk for a lower- extremity amputation. The most common components in the causal pathway to limb loss include peripheral neuropathy, ulceration, infection, and peripheral vascular disease. Ulceration is the most common single precursor to amputation and has been identified as a component in 85% of lower- extremity amputations

As Diabetic foot problems quickly reach the point of no return, it is vital to diagnose them early and provide rapid and intensive treatment. Furthermore, it is important to achieve early recognition of the at-risk foot so as to institute prompt preventive measures. The multidisciplinary foot clinic can reduce the numbers of amputations and enable us to take a new approach to the diabetic foot by early diagnosis and treatment.

. Systematically recording the characteristics of ulcerations is critical to planning treatment strategies, monitoring treatment effectiveness, predicting clinical outcomes, and improving communication among health care providers. The wound classification systems that have previously been described in the medical literature to accomplish these tasks either do not provide information about some of the most important parameters that would be expected to dictate treatment and predict outcome, or these parameters are incompletely used in the grading scheme.

Most classification systems previously reported in the medical literature have primarily focused on the depth of the ulceration and have neglected or inconsistently included infection and peripheral arterial occlusive disease . These factors have been widely discussed in the

literature. However, we are unaware of any diabetic wound classification systems that have been validated or demonstrated to predict outcome. Empirically, it seems that poor outcomes are generally associated with infection, peripheral vascular disease, and wounds of increasing depth, and that the cumulative effect of these comorbidities would progressively contribute to a greater likelihood of amputation. Therefore, the purpose of this study was to validate a wound assessment instrument based on the eventual outcome of the wound.

# AIM OF THE STUDY

1. To compare the WAGNERS and SAN-ANTONIO UNIVERSITY OF TEXAS Diabetic foot wound classification system as predictors of outcome on new Diabetic foot ulcers.
2. To assess the contribution of Depth, Neuropathy, Infection and Ischemia of the diabetic wound on the eventual outcome of the wound.

# MATERIALS AND METHODS

This study was conducted in Government Rajaji Hospital, Madurai from June 2005 to June 2006 and included 69 new cases presented to Diabetic foot clinic with a wound below ankle. Patients received some form of treatment for the Diabetic foot ulcer already are excluded from the study. As part of the protocol, patients treated for foot complications in the high-risk diabetic foot clinic have a standardized evaluation to assess wound depth, sensory neuropathy, vascular insufficiency, and infection.

The diagnosis of diabetes was verified for all patients using the criteria set forth by the World Health Organization, which include treatment with insulin or an oral hypoglycemic agent, two random glucose measurements 200 mg/dl, or a fasting glucose >126 mg/dl

Sensory neuropathy was evaluated with a 10-g Semmes - Weinstein monofilament wire and a modified neuropathy disability score.

The diagnosis of infection was made using clinical criteria. Wounds with frank purulence and/or two or more of the following local signs were classified as “infected.” These signs include warmth, erythema,

lymphangitis, lymphadenopathy, edema, pain, and loss of function. For all wounds, depth was evaluated using a sterile blunt nasal probe. If a wound probed to bone or joint, with the presence of local or systemic infection, a bone biopsy was performed with both microbiologic and histologic analysis to diagnose or exclude osteomyelitis.

A working diagnosis of lower- extremity ischemia was made by a combination of clinical and noninvasive vascular studies. Clinical signs were based on the absence of one or more foot pulses of the involved foot. Noninvasive criteria included an ankle-brachial index (ABI) of <0.80. Clinical signs and/or the presence of abnormal noninvasive values provided a diagnosis of lower- extremity vascular insufficiency.

Wounds were graded and staged by WAGNER and UNIVERSITY OF TEXAS diabetic wound classification system. Patients were treated and followed up. The nature of treatment fall in

1) Debridement of wound
2) Amputation.

To compare the level of amputation by stage and grade of wound, we stratified all lower extremity amputations in 3 levels,

1) Digit/ray amputation
2) Mid foot level amputation
3) Below knee amputation

Chisquare analysis and odds ratio was used to demonstrate the potential association between high grade wound and prevalence of high level amputation. Amputations were classified high level if they were performed at the mid foot level or proximally.

# PATHOPHYSIOLOGY OF DIABETIC FOOT

Diabetes mellitus is associated with more than half of all non-traumatic lower limb amputations. The major pathophysiology factors are ischemia, neuropathy, infection and wound healing factor. They operate concurrently and sequentially, enhancing the risk for amputation fifteen-fold in diabetic subjects compared to non diabetics. Since the diabetic foot is the sequel of interaction of multitude of factors, intervention must be directed towards correction of all causative factors.

## FACTORS OPERATIVE IN THE CAUSATION OF DIABETIC FOOT

### Vascular disease

Diabetes mellitus is associated with structural changes in large as well as small blood vessels, resulting in ischemia. The atherosclerotic process in a diabetic occurs more frequently and at an early age and advances more rapidly compared to non diabetics, and is devoid of the normal sex difference seen in the latter. The frequently associated risk factors for diabetic vascular disease include smoking, hypertension, hyperlipidemia and insulin resistance with compensatory hyperinsulinemia, besides the severity of durartion of diabetes, age and genetic factors. Smoking enhances the risk of peripheral vascular disease more than hundred times compared to non-

diabetic non-smokers. However, cessation of smoking has been associated with a decrease in the progression of atherosclerosis.

Hypertension is twice as common in diabetics as compared to non-diabetics; roughly one third to one half of diabetics have hypertension. Systolic hypertension has been linked with disease of proximal blood vessels. A significant association of hypertension with above knee and bilateral amputations has been observed.

Numerous studies allude to the strong association of hyperlipidemia with peripheral vascular disease. The ratio of LDL-cholesterol to HDL-cholesterol probably assumes greater significance in the diabetic population because the protective effect of a high HDL-cholesterol is nullified by a concomitant increase in LDL-cholesterol fraction.

**Neuropathy**

Loss of pain and thermal sensation renders the foot vulnerable to trauma due to the mechanical, chemical and thermal factors, leading to ulcerations. Loss of proprioception and muscle arophy due to motor neuropathy result in foot deformities. The resultant alteration in the configuration with new pressure points leads to callous formation and subsequent ulceration. Autonomic neuropathy with absent sweating and dry, fissured skin offering portals of entry for infection are important

contributory factors for foot ulcer. The association of autonomic neuropathy with foot ulcer is almost 100%

**Biomechanical aspects**

Combination of neuropathy and trauma results in tissue breakdown. The atrophy of the intrinsic muscle of the foot, predominantly plantar flexors of the toes alters the flexor/extensor balance at the metatorsophalangeal joints and causes clawing of the toes and prominence of the metatarsal heads. Alterations of foot shape results in increased plantar pressure. A majority of wounds on insensitive foot are not caused by accidental injury or ischemia but from continuous pressure. Often moderate stress as occurring during locomotion on the same part of the insensitive foot leads to callus formation and ulcer. The presence of callus may exacerbate the problem both acting as a foreign body and by increasing the plantar pressure.

Limitied joint mobility is yet another factor contributing to elevated plantar pressure. Glycosylation of collagen results in thickening and cross linking of collagen bundles. This result in restriction of joint movements particularly sub talar joint and alters the mechanism of walking. Limited joint mobility also occur in the hands.

**Haemorheology**

Haematocrit, plasma viscosisty, platelet activity and red blood cell aggregation constitute macro vessel haemorheology, while micro vessel haemorheology involves red blood cells and white blood cells deformability. All these components are unfavorably altered in diabetic subjects, accentuating the ischemic process due to structural changes of large and small blood vessels.

**Infection**

Frequent and severe infection in diabetic subjects is facilitated by vascular insufficiency. A normal individual responds to infection by increasing the blood supply to the site, as blood supply has to be increased 12 – 15 times to maintain the viability of the skin. If this increased demand cannot be met, the skin breaks down and tissue necrosis results. Necrosed tissue is a good nidus for organisms to thrive.

Most of the diabetic foot infections are caused by multiple organisms, including anaerobes. Bacteriods are the commonest group of pathogens isolated in culture. Soft tissue gas formation has been encountered in diabetic subjects and the capacity for gas formation is exhibited not only by the coli form group ( aerobic and anaerobic gram negative rods) but also by

streptococci and staphylococci. Ostemyelitis is observed in some of the diabetic foot lesions.

The peripheral vascular disease occurring in diabetic subjects is multisegmental with a predilection for vessels below the level of the popliteal artery; often the pathology is bilateral. These features are in marked contrast to those encountered in the non-diabetic population. Not uncommonly, the collateral vessels are also involved, with the result that gangrene occurs in patchy areas of he foot and toes, incontrast to the extensive gangrene occurring in the non-diabetic subjects.

Patients may present with intermittent claudication, nocturnal pain and rest pain, the latter two being relieved by dependency. Nocturnal pain is form of ischemic neuritis that proceeds rest pain. During sleep, the circulation predominantly caters to the splanchnic area, resulting in diminished perfusion of the lower extremites; the consequent ischemic neuritis becomes intense and disturbs form his sleep. The patient attempts to gain relief by standing, dangling the feet or occasionally walking a few steps; the resultant increase in cardiac output improves tissue perfusion, affording relief from pain. Failure of intrevention at the stages of nocturnal and rest pain ultimately results in tissue necrosis and gangrene, necessitating amputation.

On examination of an ischemic limb, the feet are cold with absent pulses, blanching on elevation with delayed venous filling. The skin appears shiny with loss of hair and thickened nails. On the other hand, the neuropathic foot will be warm and veins will be prominent on the dorsum of the foot due to arterio-venous shunts resulting from autonomic neuropathy.

**FEATURES OF THE ISCHEMIC FOOT**

- painful lesions;
- dry black gangrene either confined to a toe or the heel, or extensive and super infected
- cold feet that become pale on elevation and cyanosed on depression
- thin atrophic feet
- thickened nails;
- sparse hair
- peripheral pulses  weak or absent
- slow venous filling
- vascular investigations; ischemia
- Normal or slightly reduced reflexes and sensation

FEATURES OF THE NEUROPATHIC FOOT

- disproportion between lesions and absence of pain
- keratosis
- cracks
- ulcers and plantar ulcers
- deformity of foot and toes
- amyotropy
- loss of sense of touch
- loss of pain and vibration sensation
- loss of tendon reflexes
- warm dry feet
- venous congestion
- edema
- pulses present
- no evidence of ischemia on investigations

The vascular laboratory provides essential additional information which serves to initiate measures in the management of peripheral vascular disease. The ankle and toe pressures , ankle-brachial systolic pressure ratio( ischemic index ), the wave pattern of flow, are some of the indices routinely used in

the assessment . An ankle pressure of less than 70 mm Hg is associated with poor healing of ulcers while a pressure of more than 100 mm Hg is associated good prognosis. Similarly, a toe pressure of less than 20mm Hg has been found to be associated with increased failure of distal amputation, whilemore than 40 mmHg is associated with good prognosis. An ischemic index of 0.45 with pulsatile flow indicated healing in 93% of subjects with an index below 0.45 have to evaluated for vascular reconstruction.

However, the outcome of non invasive vascular studies should not be allowed to influence clinical judgment on site selection for amputation, because falsely high segmental systolic pressures could be obtained with a rigid calcified lower extremity artery. In fact, the importance of pulsatile wave forms on arterial impedance plethysmography is more reliable parameters of prevailing vascularity.

Sosphisticated techniques are now available for vascular assessment in predicting healing of amputation and ulcers. Skin blood flow calculated from xenon-133 clearance , a micro-invasive procedure and transcutaneous oxymexry are some of those techniques. Cutaneous blood flow of more than 2.6 ml/100g/min has been associated with good healing. However , all the above indices may fail to predict healing accurately because the state of the local wound dominates the outcome. For example, a severe infection can

dampen the beneficial effects of the marginal blood flow or occasionally even a good blood flow.

**Neuropathy**

The classical peripheral neuropathy of diabetes mellitus is often bilateral; and symmetrical. The sensory component predominates, with patients complaining of pain and paresthesias while on objective examination there is blunting of pain and temperature sensation- “the painful painless leg”. The sensory disturbances generally appear early in the distal portions of the lower extremities, eventually progressing to a stock and glove distribution. Involvement of large sensory and motor fibres impairs light touch and proprioception and causes weakness of intrinsic muscles of the feet with aleration of pressure points.

Neuropathy can be assessed by clinical examination and conduction studies. Autonomic neuropathy with its important contribution towards the propagation and maintenance of foot ulcer can be assessed at the bedside by a battery of tests. Since the peripheral nerve is the common pathway for

neural flow, severe peripheral neuropathy is manifested by autonomic disturbances in the periphery.

**Repetitive moderate stress**

In a normal as well as in insensitive feet, walking briskly is accompanied by progressive hyperemia over points of maximum stress. Thermography helps to outline the temperature contrast of progressive inflammation from such a process . in subjects with insensitive feet, the thermographic pattern shows hyperemia at sites of old scar, there by inferring that these subjects have been stressing that particular area more than optimally, due to absence of pain and as a result of motor neuropathy. Similarly, in-shoe foot prints help to detect the points of persistent and maximum stress on the feet which probably could be alleviated by proper footwear.

**Infection**

Many diabetic foot ulcers tend to be neglected because the lesion are asymptomatic. Ostemyelitis should be suspected when a non-healing ulcer overlies a bony prominence. It should however be distinguished from diabetic osteopathy and neuroarthropathy, occurring as a result of denervation. The radiological hallmark of diabetic osteopathy is the

characteristically pointed metatarsal called " the peppermint stick sign". The distribution of diabetic osteopathy is multifocal and bilateral; besides, the condition associated with normal leukocyte count and ESR. However , the distinction between osteomyelitis and osteopathy is often made on clinical grounds.

**CHARCOTS FOOT**

Charcot foot or neuroarthropathy is defined as a relatively painless , progressive, degenerative arthropathy of single or multiple joints caused by underlying neuropathy. Charcrot neuropathy is characterized by simultaneous presense of bones and joint destruction., fragmentation and remodeling. Diabetes is the commonest cause of charcot foot and most patients have a dense neuropathy but good circulation. Walking on an insensitive foot leads to excessive and repetitive stress to bone causing micro fracture and finally bone and joint destruction. Diabetic neuropathy and presence of auto sympathectomy lead to peripheral vasodilatation.(warm foot). A significant arteriovenous shunting takes place leading to abnormal bone cell activity ( osteoclastic) and eventual resorption and weakening of bone. Ultimately the foot shape is deformed and runs into a "bag of bone".

Bone and joint damage in the metatarso-tarsal region is the commonest site of involvement and leads to the two classical deformity.

- Rocker bottom deformity in which there is diaplacement and subluxation of the tarsus downward.
- Medial convexity, which results from displacement of the talo-navicular joint or from tarso-metatarsal dislocation.

Both are often associated with a bony prominence which is very prone to ulceration. Healing is notoriously difficult. If these deformities are not diagnosed early and accommodated in properly fitting footwear, ulceration at vulnerable pressure points often develops.

It is not uncommon to mistake acute charcot foot for cellulitis and osteomyelitis. If the affected foot is elevated, the erythema will recede whereas that of cellulitis will persist. Should not be mistaken for cellulitis and operated upon

Plain x-ray of the foot will show demineralization., bone destruction and periosteal reaction. Marked osseous resorption of bone results in " pencil pointing" and "sucked candy" deformities of the metatarsal heads and shafts. In the largest joints of the foot there will be destruction of bone and new bone formation.

The treatment is conservative, mainly immobilization either by total contact cast or the diabetic air cast walker with inflatable air cells. There is some evidence on that biphosphanate drugs given intravenously in the acute phase may shorten the duration of the acute phase presumably by reducing the bone turnover directly and also slowing down the process which weakens the bone and renders it susceptible for foot fracture and fragmentation.

It is a dictim that a ‘ warm swollen foot in a diabetic with neuropathy without local and systemic signs of infection, charcot foot must be considered until proven otherwise’.

# EVALUATION OF DIABETIC FOOT

## Assessment of Neuropathy

Neuropathy is the most common complication of diabetes affecting 50% of all diabetic patients.Although it may present with tingling and feeling of numbness, it is asymptomatic in majority of patients and neuropathy will be only be detected by clinical examination. An important indication of neuropathy will be a patient who fails to complain of pain, even when significant foot lesions are present.Painless ulceration is definite evidence of a peripheral neuropathy.

The presentation of peripheral neuropathy is related to dysfunction of sensory, motor and autonomic nerves. Simple inspection will usually reveal signs of motor and autonomic neuropathy but sensory neuropathy must be detected by screening or by a simple sensory examination.

### Motor Neuropathy

The classical sign of a motor neuropathy is a high medial longitudinal arch, leading to prominent metatarsal heads and pressure points over the plantar forefoot. In severe cases, pressure points also develop over the apices and dorsal interphalangeal joints of associated claw toes. However claw toe is a common deformity and may not always be related to a motor neuropathy. It may be caused by wearing unsuitable shoes or trauma or may

be congenital.

Complicated assessment of motor power in the foot or leg is not usually necessary, but it is advisable to test dorsiflexion of the foot to detect a foot drop secondary to a common peroneal nerve palsy. This is usually unilateral and will affect the patient's gait.

**Autonomic neuropathy**

The classical signs of autonomic neuropathy are:

-Dry skin with fissuring

-Distended veins over the dorsum of the foot and ankle.

**Sensory neuropathy**

Sensory neuropathy can be simply detected by,

- Monofilaments
- Neurothesiometer

If these are not available, then a simple clinical examination detecting sensation to light touch using a cotton wisp and vibration using a 128-Hz tuning fork will suffice, comparing a proximal site with a distal site to confirm a symmetrical stocking like distribution of the neuropathy.

**Monofilament**

The Semmes-Weinstein monofilament is a valuable,easy-to-use tool. The monofilament is a long nylon wire, the tip of which give a force of 10 grams is pressed perpendicularly against the skin to the point of buckling for at least one second .The points of testing are plantar aspects of $1^{st}$ ,$3^{rd}$ and $5^{th}$ digits, the plantar aspects of $1^{st}$ , $3^{rd}$ , $5^{th}$ ,metatarsal heads, the plantar midfoot medially and dorsally and the plantar heel(10 sites totally). Neuropathy, is said to exist when 4 out of these 10 sites show absence of sensation when the wire is pressed against the skin.

An alternate method of testing neuropathy is use of biothesiometer (Vibration perception threshold meter). This has a hand-held probe whose tip vibrates at 100Hz The voltage supplied to the probe can be adjusted from 0 to 50V.the probe is placed against the skin and voltage increased till he perceives the vibration. Mean of three readings is used to determine the VPT for each foot. Normal reading should be less than or equal to 25V.

## Modified Neuropathic Disability Score (NDS)

### NDS

| | | Right | Left |
|---|---|---|---|
| **VPT**<br>128 Hz tuning fork; apex of big toe; normal = can distinguish vibrating / not vibrating | Normal = 0; abnormal = 1 | | |
| **Temperature perception on dorsum of the foot**<br>Use tuning fork with beaker of ice/warm water | | | |
| **Pin prick**<br>Apply pin proximal to big toenail just enough to deform the skin; trial pair = sharp, blunt; normal = can distinguish sharp / not sharp | | | |
| **Achilles reflex** | Present = 0<br>Present with reinforcement = 1<br>Absent = 2 | | |
| **NDS total out of 10** | | | |

The maximum NDS score is 10,with a score of 6 or more being predictive of foot ulcer risk.

**Assessment of Peripheral vasculature**:

This includes palpation of the pulses(dorsalis pedis. Posterior tibial, popliteal and femoral). Absense of distal pulses in a diabetic foot is a sure sign of significant arterial disease. However, presence of palpable pulse does not absolutely exclude vascular disease.

Ankle brachial index is a simple method of assessing vascular insufficiency. It is obtained by dividing the ankle systolic pressure by the brachial systolic pressure. Normal values are 1.0_+ 0.1. however,the ABI can be deceptive because calcification of vessels in diabetes can lead to falsely elevvated ABI.

If facilities are available, one can make a more detailed assessment of peripheral circulation by measuring toe pressure (using a photoplethysmograph). Normal systolic toe pressure is >4KPA. Transcutaneous oxygen tension (N>40mmHg) is another noninvasive test of circulation in the periphery. Reduced oxygen tension is associated with significant vascular disease and so, transcutaneous oxygen tension has been used to assess ulcer healing potential and also determine amputation levels.

Once occlusive vascular disease has been diagnosed, it may be assessed in detail using duplex scanning of the arterial system. If vascular reconstruction is planned, an angiogram is considered. However, angiogram, despite being the gold standard, has severe limitations since we may not be able to use it in patients with diabetic nephropathy.

## Assessment of osteopathy

Plain X-rays are not always reliable in diagnosis of early osteomyelitis, though diagnosis of advanced osteomyelitis is relatively straightforward. It is difficult to differentiate between osteomyelitits and diabetic osteoarthropathy. It is reasonable to presume that osteomyelitis exists if one is able to probe to bone during clinical evaluation of an ulcer.

### Deformity

It is important to recognize deformity in the diabetic foot. Deformity often leads to bony prominences, which are associated with high mechanical pressures on the overlying skin. This results in ulceration, particularly in the absence of protective pain sensation and when shoes are unsuitable. Ideally, the deformity should be recognized early and accommodated in properly fitting shoes before ulceration occurs. Common deformities includes,

- claw toes
- pes cavus
- hallux rigidus
- hallux valgus
- hammer toe
- mallet toe
- Fibro-fatty padding deletion
- Charcot foot
- Deformities related to previous trauma and surgery
- Nail deformities

**Callus**

This is thickened area of epidermis which develops at sites of pressure, shear and friction. It should not be allowed to become excessive as callus is a common forerunner of ulceration in presence of neuropathy

**Swelling**

Swelling of the tissues of the foot is a major factor predisposing to ulceration and organ exacerbates a tight fit inside poorly fitting shoes. It also impedes healing of established ulcers.

**Skin breakdown**

An active search should be made for breaks in the skin over the entire surface of the foot and ankle, not forgetting the areas between the toes and at the back of the heal. Toes should be gently held apart for inspection. If jerked apart, this can split the skin. The classical sign of tissue breakdown is the foot ulcer. However, fissures and bullae/blisters also represent breakdown of the skin.

Some lesions will be obvious; others will make their presence known by their complications such as;

- Discharge or exudates
- Colour changes under callus or nail plate
- Pain or discomfort
- Swelling
- Warmth
- Erythema

**Infection**

When skin breakdown develops, it may act as a portal of entry for infection. A close inspection for signs of infection should be made. These include purulent discharge from the lesion and erythema swelling and

warmth of the toe or foot.

**Necrosis**

Finally, lesions of skin breakdown may progress to underlying necrosis. This can be identified by the presense of black or brown devitalized tissue.

**INTEGRATED EXAMINATION:**

In practice, the examination of the foot should be divided into three main parts: inspection, palpation and neurological examination.

**Inspection**

The foot should be fully inspected including dorsum ,sole , back of the heel and interdigital areas with a full assessment.

- colour ( as an indicator of ischemia)
- deformity
- swelling
- callus
- skin breakdown
- infection

- necrosis

**Palpation**

Pulses should be palpated and skin temperature compared between both feet with the back of the examining hand. The measurement of the skin temperature is particularly helpful in the management of the charcot foot when a digital skin thermometer is useful.

**Neurological assessment**

Peripheral Neuropathy should be detected either by using he monofilament or neurothesiometer or by performing a simple sensory examination.

# CLASSIFICATION OF DIABETIC FOOT

## Wagner Classification

Grade 0 – No ulcer but high risk foot (Deformity or cellulitis)

1 – Superficial diabetic ulcer (Partial / full)

2 – Ulcer extension to ligaments, tendon, Joints, Capsule, or deep fascia without abscess and /or osteomyelitis

3 – Deep ulcer with abscess / osteomyelitis / Joint sepsis.

4 – Gangrene localized to portion of fore foot ( toe / heel)

5 – Extensive gangrenous involvement of entire foot.

## II. SAN-ANTONIO UNIVERSITY OF TEXAS WOUND CLASSIFICATION

| STAGE | GRADE | | | |
|---|---|---|---|---|
| | 0 | 1 | 2 | 3 |
| A | PRE/POST ULCER LESION NO SKIN BREAK | SUPERFICIAL ULCER | DEEP ULCER TO TENDON & CAPSULE | WOUND PENETRATING TO BONE/JOINT |
| B | + INFECTION | + INFECTION | + INFECTION | + INFECTION |
| C | + ISCHEMIA | + ISCHEMIA | + ISCHEMIA | + ISCHEMIA |
| D | + INFECTION & + ISCHEMIA | + INFECTION & + ISCHEMIA | + INFECTION & + ISCHEMIA | + INFECTION & + ISCHEMIA |

III. SAD (SIZE, AREA, DEPTH) SYSTEM – MAC FARLANE & JEFFCOATE

IV. FOSTERT EDMONDS - 6 STAGES

# MANAGEMENT OF DIABETIC FOOT

## (a) WAGNER grade 0 foot:

This includes patients with apparently normal foot, varying degrees of neuropathy or joint deformities. They may not have any ulcer or infection but are potentially “at risk”. They need regular assessment at least annually, Neuropathy must be looked for during each assessment. The best way to prevent neuropathy or delay it is to keep blood sugar under control.

Assessment of vascular status is also mandatory. Absent foot pulses even in the absence of claudication or rest pain indicates significant vascular disease and such patients may be suitable candidates for vascular reconstruction or angioplasty. Remember that a diabetic may not manifest claudication symptoms if he had neuropathy.

These “at risk” patients may have elevated pressures over some points on the sole. They need appropriate footwear (extra depth shoes with cushioned insoles). Sometimes, even surgical removal of metatarsal heads may be needed to reduce local elevated pressures. Charcot’s feet may need custom shoes.

Regular trimming of callus is needed. These patients also need advice regarding care of feet/pedicure.

**(b) WAGNER grade 1 foot**

These are patients who have presented with either cellulitis or a superficial ulcer. Ulcer occur either with repetitive low pressure or sustained high pressure(>6 kg/cm) at that point on the sole during walking.

Relief of pressure is the mainstay of ulcer treatment. An ulcer will not heal if the patient walks on it. A variety of ways are available to "off load" the ulcer. These include complete bed rest, use of total contact casts walkers, braces etc.

As in the case of grade 0 feet, appropriate management of vascular disease is needed. Infection needs antibiotics and debridement as appropriate.

Education, foot care, footwear and regular careful follow up are the principle factors in management of grade 1 feet.

**(3) WAGNER grade 2 and 3 feet:**

These are patients with deep ulcers with or without complications like abscesses and osteomyelitis. These patients need aggressive surgical debridement. Osteomyelitis must be appropriately managed by debridement/excision of infected bone.

Once the ulcer has healed, the patient needs long-term care to devise appropriate foot wear and also education regarding foot care, in order to avoid recurrence.

**(4) WAGNER grade 4 and 5 feet:**

These are patients who have either localized or extensive gangrene. They need minor or major amputations respectively. Almost always there is vascular occlusive disease.

These patients therefore need appropriate surgical amputation followed by vascular reconstructions.

After-care involves special footwear for the ipsilateral and contralateral foot.( These patients tend to over- use the other foot and develop ulcers of the opposite foot). In case of major amputees, prosthetic devices need to be fitted in order to mobilize the patient. Mortality rate of diabetes after a major amputation is nearly 50%at one year.

**FOOTWEAR RECOMMNDATIONS IN DIABETICS:**

The recommendations are based on the following grading:

| Risk Class | Features |
|---|---|
| 0 (low risk) | Has normal protective sensations |
| 1(medium risk) | Has neuropathy but no deformity or previous ulceration /amputation |
| 2(high risk) | Neuropathy + deformity present But no previous ulceration/amputatiom |
| 3(very high risk) | Neuropathy + deformity + history of Previous ulcer/amputation |

**Risk class 0:**

Essentially normal patients. They need to be advised to wear shoes with thick sole (to absorb vertical compressive forces) with soft uppers ( to mould foot shape and avoid shoe bite) with ample toe box (to be able to wiggle toes),

**Risk class 1**:

They are potential candidates for ulcerations, since they have no protective sensation. These patients need advice on foot care (do not walk barefoot, avoid bathroom surgery, avoid extremes of temperature while washing feet), in addition they need foot wear that satisfies all criteria for class ‘o’ but also has a pressure dissipating accommodative insole ( to avoid local high pressures)

**Risk class 2:**

These are neuropathic patients with foot deformity (such as bunions, claw toe, hammer toe). They need a footwear with extra soft accommodative uppers that mould to the foot’s shape while allowing enough space for toe movement. The sole may need to have recessed heel ( to reduce impact at “heel strike” phase of gait) along with angulation of the sole just behind the metatarsal heads ( so that a rolling motion is obtained during walking- like a ‘rocker-bottom’). A total contact insert is beneficial.

**Risk class 3:**

These are patients who have already ulcerated once and are likely to do so repeatedly. The need footwear recommendations as for a grade2 -well fitting shoes with a rocker bottom sole and moulded insoles.

In case of patients with active ulceration, various options are available

to off- load the foot. These are:

1. total contact cast.
2. air cast or patellar tendon weight bearing brace.
3. temporary shoes( talus shoes, which has no sole in the front so that patient walks only on heel.
4. customized foot wear ( applicable to patients with charcot's foot who have disrupted bony architecture of foot).

**ADJUNCTIVE THERAPY FOR WOUND HEALING**

Investigations have shown that autologous platelet-derived growth factor formula (PDGF) can be an important adjunct to heal wounds that have shown resistance to comprehensive approaches. Steed has shown than recombinant PDGF significantly achieved complete healing in diabetic foot wounds when compared to standards of care alone. Recombinant PDGF in a gel caplermin is applied once a day to the wound and covered with moist gauze dressing. A dressing change without PDGF is applied approximately 12 hours later. PDGF should not be used when there is extensive necrosis, active infection, and/or ischemia.

The use of living tissue equivalent is another new technique for accelerating wound healing in diabetic foot ulcers. Dermagraft is derived from cultured human dermis. It is derived from foreskin tissue cultures.

Dermagraft consists of neonatal dermal fibroblasts cultured in vitro onto a bioabsorbable mesh. This produces living metabolically active tissue containing normal growth factors and cytokines.

Hyperbaric oxygen (HBO) is gaining favor as treatment for diabetic foot wounds. Orianni et al. found that amputation rates in 62 diabetics who were treated for foot ulcers with HBO was only 4% compared to 49%of the control group who were unable or unwilling to undergo the therapy with HBO . Systemic hyperbaric oxygen greatly increases tissue oxygen levels. Oxygen tension values remain elevated for several hours after exposure. It must be kept in mind that HBO is a supplemental treatment to standard wound care. It is ineffective in patients with severe peripheral vascular disease. Hyperbaric oxygen delivered by a hyperbaric boot is of no value. It must be delivered by putting the patient into single or multiple person chambers.

Electrical stimulation is another form of therapy for wound healing. William gilbert proposed the use of electrical stimulation for wound healing as far back as 1600. This was followed by a number of contributions over the years. Wood and colleagues found the pulse lower intensity direct current represented a useful approach for the treatment chronic ulcers.

Recently, Baker et al. found that electrical stimulation given daily with short pulsed asymmetric biphasic waveform was effective for enhancement of healing rates for patients with diabetes and open wounds. Using this technique they found a significant increase in the healing rate by nearly 60% in patients treated with electrical stimulation compared to controls. Patients treated with asymmetric biphasic square wave pulse did not show increased wound healing. Lundeberg et al, have also reported improved healing of diabetic ulcers using electrical nerve stimulation.

Ultrasound has also been suggested as a treatment for healing diabetic wounds. Ultrasound refers to high-frequency, mechanical vibrations that are produced when electrical energy is converted to sound waves. Ultrasound gets its name because the sound is beyond the range of human hearing. Ultrasound may be helpful because of its stimulatory effects in fibroblasts and macrophages and on angiogenesis. Ultrasound can cause dire consequences when applied in an improper manner, and this may result in tissue destruction.

Again, it must be kept in mind that wound healing using electrical stimulation or ultrasound is still experimental and further control studies will be necessary to prove conclusively their efficacy in the treatment of diabetic foot wounds.

# OBSERVATIONS AND RESULTS

In our study, Diabetic foot ulcer was more common in males. Out of 69 patients, 44 were males (63.8%) and 25 were females (36.2%).

| SEX | PATIENTS | |
|---|---|---|
| | No. | % |
| Male | 44 | 63.8 |
| Female | 25 | 36.2 |

The most common age group affected was between 50 to 70 years in both males and females. Mean age is 59.5 +_ 8.7 years.

| A. CHARACTERISTICS OF PATIENTS | | |
|---|---|---|
| AGE | PATIENTS | |
| | No. | |
| | 2 | 2.9 |
| | 8 | 11.6 |
| | 28 | 40.6 |
| | 27 | 39.1 |
| | 4 | 5.8 |
| | 69 | 100 |
| | 59.5 years | |
| | 8.7 | |

| A. CHARACTERISTICS OF PATIENTS | | |
|---|---|---|
| AGE | PATIENTS | |
| | | |

In our study, 39 patients presented with ulcer on Right side ( 55.9%) and 24 on left side (35.3%). 5 patients presented with ulcer on both sides(7.4%).

| Ulcer side | PATIENTS | |
|---|---|---|
| | No. | % |
| Right | 39 | 55.9 |
| Left | 24 | 35.3 |
| Both | 5 | 7.4 |
| | | |
| **Ulcer site** | **PATIENTS** | |
| | **No.** | **%** |
| Toe | 15 | 21.7 |
| Web space | 14 | 20.3 |
| Dorsum | 23 | 33.4 |
| Sole | 17 | 24.6 |

| Ulcer site | PATIENTS | |
|---|---|---|
| | No. | % |
| | | |

In our study, 48 patients presented with ulcer on a single site on the foot and 21 patients presented with ulcer on more than one site on the foot. Among sites, Dorsum of foot were more common(33.4%)

# Prevalence of wound in wagner and University of Texas grading

| Stage | Grade | | | |
|---|---|---|---|---|
| | 0 | 1 | 2 | 3 |
| A | Pre/post ulcer lesion No skin break _ | Superfecial ulcer 2.9% | Deep ulcer to tendon & capsule _ | Wound penetrating to bone/Joint _ |
| B | + Infection 21.7% | + Infection 14.5% | + Infection 20.3% | + Infection 8.7% |
| C | + Ischemia _ | + Ischemia _ | + Ischemia | + Ischemia |
| D | + Infection & +Ischemia 1.4% | + Infection & + Ischemia 13% | + Infection & + Ischemia 7.2% | + Infection & + Ischemia 10.1% |

**PREVALANCE OF WOUND IN WAGNERS CLASSIFICATION**

| | |
|---|---|
| **Grade 0** | **4.3%** |
| **Grade 1** | **20.3%** |
| **Grade 2** | **34.8%** |
| **Grade 3** | **13%** |
| **Grade 4** | **24.6%** |
| **Grade 5** | **2.9%** |

| TREATMENT | PATIENTS | |
|---|---|---|
| | No. | % |
| Debridement | 44 | 63.8 |
| Toe/Ray amputation | 8 | 11.6 |
| Mid foot amputation | 3 | 4.3 |
| BK Amputation | 14 | 20.3 |

In our study, 25 patients received some form of amputation(36.2%).

## PREVALANCE OF AMPUTATION IN WAGNERS CLASSIFICATION

| | |
|---|---|
| **Grade 0** | **0%** |
| **Grade 1** | **0%** |
| **Grade 2** | **4.2%** |
| **Grade 3** | **55.6%** |
| **Grade 4** | **58.9%** |
| **Grade 5** | **100%** |

**PREVALANCE OF AMPUTAION IN UNIVERSITY OF TEXAS**

**CLASSICATION**

| Stage | Grade | | | |
|---|---|---|---|---|
| | 0 | 1 | 2 | 3 |
| A | Pre/post ulcer lesion No skin break _ | Superfecial ulcer 0% | Deep ulcer to tendon & capsule _ | Wound penetrating to bone/Joint _ |
| B | + Infection – | + Infection 10% | + Infection 14.3% | + Infection 50% |
| C | + Ischemia – | + Ischemia _ | + Ischemia | + Ischemia |
| D | + Infection & +Ischemia _ | + Infection & + Ischemia 33.4% | + Infection & + Ischemia 100% | + Infection & + Ischemia 100% |

## RELATIONSHIPS BETWEEN WAGNER CLASSIFICATION AND TREATMENT

| Ulcer Grade | Treatment | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Debridement | | Toe/Ray amputation | | Mid foot amputation | | BK Amputation | |
| | No. | % | No. | % | No. | % | No. | % |
| 0 (3) | 3 | 100 | - | - | - | - | - | - |
| 1 (14) | 13 | 92.9 | 1 | 7.1 | - | - | - | - |
| 2 (24) | 23 | 95.8 | - | - | 1 | 4.2 | - | - |
| 3 (9) | 4 | 44.4 | 1 | 11.1 | 1 | 11.1 | 3 | 33.3 |
| 4 (17) | 1 | 5.9 | 6 | 35.3 | - | - | 10 | 58.8 |
| 5 (2) | - | - | - | - | 1 | 50 | 1 | 50 |
| < Grade 2 (41) | 39 | 95.1 | 1 | 2.4 | 1 | 2.4 | - | - |
| > Grade 2 (28) | 5 | 17.9 | 7 | 25 | 2 | 7.1 | 14 | 50 |
| p | 0.0001 | | | | | | | |

ODDS ratio is 54.

As ulcer grade increase, seriousness of the problem and treatment also increases.

This increase is statistically significant.

Patients were more than 54 times more likely to receive a mid foot or higher level amputation if their wound probed to bone ( grade 3)

## RELATIONSHIP BETWEEN NEUROPATHY AND TREATMENT

| Neuropathy | Treatment | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Debridement | | Toe/Ray amputation | | Mid foot amputation | | BK Amputation | |
| | No. | % | No. | % | No. | % | No. | % |
| Present (56) | 32 | 57 | 7 | 12.5 | 3 | 5.4 | 14 | 25 |
| Absent (13) | 12 | 92.3 | 1 | 7.7 | 0 | - | 0 | - |
| p | **0.015 ( Significant)** | | | | | | | |

30% of patients with Neuropathy received high level amputation. All patients without Neuropathy did not receive mid foot or higher level amputation. Thus presence of neuropathy increases severity of treatment. This relationship is statistically significant.

**RELATIONSHIP BETWEEN PALPABLE PULSE AND TREATMENT**

| Palpable Pulse | Treatment | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Debridement | | Toe/Ray amputation | | Mid foot amputation | | BK Amputation | |
| | No. | % | No. | % | No. | % | No. | % |
| Yes (52) | 40 | 76.9 | 8 | 15.4 | - | - | 4 | 7.7 |
| No (17) | 4 | 23.5 | - | - | 3 | 17.6 | 10 | 58.8 |
| P | 0.0002 | | | | | | | |

76.4% of patients with non-palpable pulse received mid foot or higher level amputation. Thus palpation of pulse and ulcer treatment have a statistically significant association.

**RELATIONSHIP BETWEEN UNIVERSITY OF TEXAS CLASSIFICATION AND TREATMENT**

| University of Texas Grade | Non-Amputation | | Amputation | |
|---|---|---|---|---|
| | No. | % | No. | % |
| 0a,1a,2a,3a | 2 | 100 | - | - |
| 0b,1b,2b,3b | 40 | 88.9 | 5 | 10.1 |
| 0c.1c,2c,3c | - | - | - | - |
| 0d,1d,2d,3d | 2 | 9.1 | 20 | 90.9 |
| P | 0.0001 | | | |

ODDS ratio is 84.

90.9% patients presented in "stage d" received mid foot or higher level amputation.There is statistically significant relationship between university of texas grade and treatment.

Patients presented with ischemia and infection were nearly 84 times more likely to receive a midfoot or higher amputation compared with patients in less advanced wound stages.

**Statistical techniques.**

Data collected in the questionnaire were tabulated in a master chart. Analysis of the data was done by using the software "Epidemiological information package 2002" developed for World Health Organisation".

## DISCUSSION

**Age and sex:**

In our study, Diabetic foot ulcer was more common in males(63.8%). The most common age group affected was between 50 to 70 years in both males and females. Mean age is 59.5 +_ 8.7 years.

**Site:**

Among sites, Dorsum of foot were more common and 21 patients presented with ulcer on more than one site of the foot

**Depth:**

In our study, 82.1% of patients units more than grade 2 in wagners classification received some form of amputation

Paients were 54 times more likely to receive a mid foot or higher level amputation if their wound probed to bone.

**Infection:**

Many of our patients presented with infection and so most of them were grouped under high grade and hence eventually they received some form of amputation. Those who presented in early stages were treated without amputation.

**Neuropathy:**

30% of patients who presented with Neuropathy were amputated at mid foot level or proximally and it was statistically significant.

**Ischemia:**

82.4% of patients without papable pulses went in for ischemic stage ("stage c or d") and it was stastistically significant.

90% of patients with ischemia and infection (statge d) received mid foot or higher level amputation and they were nearly 84 times more prone for the same  compared with the patients in less advanced wound stages.

# Conclusion

- There was a significant overall trend towards an increased prevalence of amputation as wound increased in stage and grade in both wagner and university of Texas diabetic wound classification system.

- Inclusion of stage in the university of Texas classification system makes it a better predictor of outcome.

- Patients were 54 times more likely to receive a midfoot or higher amputation if their wound probed to bone ( grade 3 in wagner classification).

- Patients with infection and ischemia ( “stage d” in university of Texas classification), were nearly 84 times more likely to receive a midfoot or higher amputation compared with patients in less advanced wound stages.

- There were no lower extremity amputation of any level in “stage a” (non-infected, non-ischemic) wounds, regardless of depth in university of Texas classification.

- Significantly many of patients in ischemic stages who had non-palpable pulses were more prone for amputation.

- Significant proportion of patients presented with neuropathy, went in for amputation.

- Thus Depth of ulcer, ischemia, infection and Neuropathy play a definite role in the outcome of the wound and it can be detected by simple examination and non invasive test.

- Awareness of Diabetic foot complications has to be increased among the diabetic patients and their relatives by educating them, since the outcome was very good in early diagnosis of Diabetic foot.

- All newly diagnosed diabetics, must be evaluated for Diabetic foot and foot care has to be given routinely to prevent the Diabetic foot complications at latter date.

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**PROFORMA**

Name :

Age :

Sex :

IP No :

Date of First Visit :

Complaints Duration

- Ulcer
- Swelling
- Pain

Mode of onset of Ulcer:

- Trivial
- Any Injury
- Traumatic
- No specific Injury
- Purulent
- Any discharge
- Foul Smelling
- Progression of Ulcer
- Pain
- Any Restriction of movements

Swelling:

- How it started
- Any Progression
- Unilateral / Bilateral
- Any decrease in swelling while getting up
- Any increase in swelling on work

Claudication pain

Parasthesia / Numbness / Loss of Sensation

H/O Diabetes mellitus

- Duration
- Regular
- Any
- Irregular
- Nature of treatment
- Any Periodical evaluation
- H/O Hypertension and Coronary artery Heart Disease

General; Examination

- Examination of peripheral pulses

| **Pulses** | **Right** | **Left** |
|---|---|---|
| Femoral | | |
| Popliteal | | |
| Posterior tibial | | |
| Dorsalis pedis | | |

- Ankle brachial pressure index

| | **Right** | **Left** |
|---|---|---|
| Brachial pressure | | |
| Ankle pressure | | |

– **Modified Neuropathic Disability Score (NDS)**

| | | Right | Left |
|---|---|---|---|
| **VPT**<br>128 Hz tuning fork; apex of big toe; normal = can distinguish vibrating / not vibrating | Normal = 0; abnormal = 1 | | |
| **Temperature perception on dorsum of the foot**<br>Use tuning fork with beaker of ice/warm water | | | |
| **Pin prick**<br>Apply pin proximal to big toenail just enough to deform the skin; trial pair = sharp, blunt; normal = can distinguish sharp / not sharp | | | |
| **Achilles reflex** | Present = 0<br>Present with reinforcement = 1<br>Absent = 2 | | |
| **NDS total out of 10** | | | |

– Monofilament test

Ulcer

- Site
- Size
- Shape
- Margin
- Edge
- Base
- Depth
- Any erythema

Examination of Reginal Lymphnode

Blood sugar value

- Random 1
- Random 2
- Fasting
- Post prandiod

Culture and sensitivity of pus from wound