Home Visit Education Regarding Diabetic Foot Care Among Diabetes Mellitus Patient

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Introduction

Hyperglycemia is a prevalent metabolic disease that belongs to the group of conditions known as diabetes mellitus. Due to numerous, long-lasting complications, diabetes affects practically all of the body's systems (**Janmohammadi et al., 2010**). Diabetes has become an epidemic on a global scale. According to the International Diabetes Federation (IDF), 628 million people will have diabetes mellitus by the year 2045, up from 425 million in 2017. Currently, Sub-Saharan Africa has the highest global diabetes burden (**Cho et al., 2018, Elbarsha et al., 2019**). In 2013, diabetes resulted in 56 million Disability Adjusted Life Years (DALYs) and 1.3 million fatalities (2.4% of all deaths). From 589.9 per 100,000 in 1990, the DALY rate for diabetes climbed to 883.5 per 100,000 in 2013. Ageing and age-specific DALY rates increased by 31.8 and 53.9%, respectively, while population growth increased by 62.9% and 148.6%, respectively, during the 1990s to 2013 (**Moradi-Lakeh et al., 2017**).

The term "diabetic foot" refers to the foot of people with diabetes who also have neurological disorders, various degrees of lower limb peripheral vascular disease, and deep tissue ulceration, infection, and/or destruction. It is a serious complication of diabetes that can be avoided by patient education and prompt diagnosis and treatment due to its high mortality, morbidity, and medication costs (**Bus et al., 2016, van Netten et al., 2016**). Diabetes foot issues are a leading cause of hospital admissions for diabetic patients and are crucial determinants of their quality of life (**Iraj et al., 2013, Lipsky et al., 2016**). In industrialised nations, diabetic foot ulcers (DFUS) account for 12–15% of the entire expense of diabetes, but this percentage rises to 40% in developing nations (**Solan et al., 2017**). With a prevalence of 4 to 10%, DFUs are one of the most prevalent diabetic complications in the affected population (**Haq et al., 2017**). More than 100,000 diabetic foot amputations occur each year due to non-healing lesions, and in 60% of cases, a foot ulcer was the initial cause. The societal impact of the diabetic foot is significant, estimated to be more than $1 billion yearly, in terms of personal impairment leading to hospitalizations and medical expenses (**Bandyk, 2019**). If the patient with diabetic foot ulceration does not receive the necessary care, the infected ulcers could result in serious infections, gangrene, and even death (**Chammas et al., 2016**). Diabetes foot issues not only result in patients losing their employment and money, interfering with their educational pursuits, and harming their social interactions, but they also have indirect psychological effects on patients and their settings (**Cavanagh et al., 2005**).

The identification and management of risk factors is necessary to prevent complications with diabetic feet. Peripheral neuropathy, peripheral vascular disease, foot deformity, previous foot ulceration, and foot or limb amputation are the most important risk factors for foot ulcers (**Loveman et al., 2009, Kasiya et al., 2017**). The most frequent causes of foot

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ulcer formation in patients are recurrent chronic abrasions, minor abrasions, bullae, various irritations, verrucas and calluses, excessive toenail cutting, fungal infection, poor foot hygiene, the wrong choice of footwear, and poor metabolic regulation (**Loveman et al., 2009, Iraj et al., 2013**). Due to these advancements, it is simpler to traumatise the feet and for wounds to heal slowly, which raises the possibility of infection. Every diabetic patient should have their feet inspected for potential problems at least once a year, and those who have risk factors should have their feet tested every three to six months to keep track of those risk factors (**Bus et al., 2016**, **van Netten et al., 2016**). The main components of diabetic foot management are the diagnosis of the foot at risk, routine assessment of the foot at risk, education of patients, families, and health-care providers, care of non-ulcerative diseases, and management of diabetic ulcers (**American Diabetes Association, 2013**). Patients should also address additional risk factors, such as high blood pressure, alcohol use, smoking, high cholesterol, obesity, and visual impairment (**Alexiadou and Doupis, 2012, Schaper et al., 2016**).

To avoid the significant complications of ulceration and amputation, high-risk feet are identified by foot screening and assessment. During diabetic foot examinations, protective sensory perceptions, foot structure and biomechanics, vascular structure, and skin integrity should be evaluated (**Cavanagh et al., 2005, Clarke and Tsubane, 2008**). A foot at risk is examined for vascular (limping, rest pain, and palpation of the foot pulse), skin (calluses, colour, heat, edoema, texture, and foot ulcer), and bone/joint status (amputation, Charcot deformity, drop foot, and joint limitation) (**Bakker et al., 2012, American Diabetes Association, 2013**). During neurological examinations, diabetic people should be questioned about any signs of neuropathy. An affordable, painless, and straightforward technique is utilised to gauge the loss of protective sensation in the foot: the 10-g Semmes-Weinstein monofilament set (**Waheida et al., 2015, Schaper et al., 2016**). Several places on the patient's plantar and dorsal surfaces receive 10 g of pressure. The foot is in danger and the protective sense has vanished if sensory loss is noticed during patient assessments utilising this filament (**Boulton et al., 2008**). A vibration test (with a 128-Hz tuning fork or biothesiometer), pinprick sensation, or ankle reflexes are utilised to validate the diagnosis of the foot at risk (**Clarke and M. Tsubane, 2008, Waheida et al., 2015**). Patients with neuropathy should be cautious while selecting shoes, especially if they have foot abnormalities or a history of ulcers or amputations. To stop recurring plantar foot ulcers, a patient at risk should be advised to use therapeutic shoes that reduce plantar pressure (**Bakker et al., 2012, Bus et al., 2016**). Data gathered during the foot exam is used to determine which people are at risk for developing diabetic foot issues (**Boulton et al., 2008**). The diabetic foot requires long-term care from a variety of specialties, hence a multidisciplinary team approach is necessary (**Alexiadou and Doupis, 2012, Yazdanpanah et al., 2015**). Working as a multidisciplinary team may lower the rate of foot ulcers and amputations, lower healthcare costs, and improve the quality of life for diabetic foot ulcer patients (**Aydin et al., 2010, Aalaa et al., 2012**). A general practitioner, nurse, educator, podiatrist, orthotist, vascular surgeon, infectious disease expert, dermatologist, endocrinologist, dietitian, and orthopaedic surgeon typically make up the diabetic foot care team (**Clarke and Tsubane, 2008**, **Yazdanpanah et al., 2015**). Despite the fact that all team members should educate the patient, the nurse and podiatrist are frequently the patient's primary sources of information (**Aalaa et al., 2012**).

Foot disorders can be brought on by inadequate education and awareness of basic foot care (**Monami et al., 2015**). The frequency of foot ulcers and amputations is reduced by taking a specific course in foot and wound care, and current recommendations call for patient education as a prerequisite for ulceration prevention (**Gershater et al., 2011**). The key to preventing diabetic foot ulcers is educating patients about proper foot care. The training's objectives are to encourage the patient and teach them the necessary skills to make the most use of preventive measures (**Iraj et al., 2013**).

Literature review

Pathogenesis

The traditional trio of neuropathy, ischemia, and infection describes DFU (**Pendsey, 2010**). Reduced cell and growth factor responsiveness, decreased peripheral blood flow, and decreased local angiogenesis are only a few of the mechanisms that contribute to infection risk and inadequate wound healing in DM due to compromised metabolic processes (**Brem and Tomic-Canic, 2007**). As a result, peripheral vascular disease, peripheral nerve injury, deformities, ulcerations, and gangrene are more likely to occur in the foot.

- **Neuropathy**

Patients with both type 1 and type 2 DM are susceptible to neuropathy, which accounts for about 60% of foot ulcers. Aldose reductase and sorbitol dehydrogenase, for example, become more active when blood glucose levels rise. These enzymes transform glucose into sorbitol and fructose. As these sugar byproducts build up, myoinositol production in nerve cells is decreased, which affects nerve transmission (**Clayton and Elcasy, 2009**). In addition, hyperglycemia-induced microangiopathy causes irreversible harm to the immune, metabolic, and sensory, motor, and motor nerves (**Younger et al., 1998**). This impairs the nerve innervations of the tiny foot muscles and the fine vasomotor regulation of the pedal circulation, which reduces peripheral sensation (**Jeffcoate and Harding, 2003**). The autonomic nerve system is also impacted by DM, which causes dryness and skin fissures that can get infected. The microcirculation of the skin is likewise governed by the autonomic system. These alterations eventually result in ulcers, gangrene, and limb amputations (**Vinik et al., 2003**). Peripheral neuropathy has also been linked to Charcot neuroarthropathy (**Perrin et al., 2010**).

- **Vasculopathy**

In the peripheral arteries, hyperglycemia results in aberrant smooth cells and endothelial cell dysfunction. Nitric oxide is produced by endothelial cells, which also generate vasodilation and shield blood vessels from endogenous damage. Nitric oxide's physiological functions, which typically control endothelium homeostasis, anticoagulation, leukocyte adhesion, smooth muscle cell proliferation, and antioxidant capacity, are thus disturbed in hyperglycemia. Vasodilators and endothelium-derived nitric oxide are decreased, which causes the blood arteries to tighten (**Creager et al., 2003**) and tendency to develop atherosclerosis (**Dokken, 2008**), leading ultimately to ischemia Additionally, ischemia can happen when there are audible pedal pulses. Due to arteriolar-venular shunting, the microcirculation is regularly interrupted, limiting blood supply to the area of demand (**Jeffcoate and Harding, 2003**). DM hyperglycemia and the rise in thromboxane A2 that causes hypercoagulability in plasma are related (**Paraskevas et al., 2008**).

- **Immunopathy**

An individual with diabetes has a substantially lower immune system than someone in good condition. As a result, a diabetic patient's foot infection is a disabling and limb-threatening condition. Hyperglycemia worsens polymorphonuclear cell functions such as chemotaxis, adhesion, phagocytosis, and intracellular killing. Pro-inflammatory cytokines are also elevated (**Gupta et al., 2007**). High blood glucose levels are also a favourable environment for the growth of bacteria. Aerobic gram-positive cocci, such as S. Aureus and β-hemolytic streptococci, are the main causes of diabetic foot infections (**Lipsky et al., 2004**). However, gram-negative aerobes were the predominate bacteria in a diabetic foot study conducted in India. (**Gadepalli et al., 2006**).

- **Mechanical stress**

Injury to foolish limbs is frequently disregarded. The injury to the innervations of the foot muscles affects the foot's motions, particularly flexion and extension. It eventually causes changes to the foot's anatomical structure and the development of abnormalities. In turn, the abnormalities create unusual bony prominences and pressure sites that are over time susceptible to ulcers. As the metatarsal fat pads move distally, the cushioning properties of the metatarsal heads are diminished, and pressure sites that result in callus forms and skin breakdown and ulceration are increased (**Bowering, 2001**). On the heel and plantar area of the great toe, ulcers frequently develop. Uncomfortable shoes,

nevertheless (which are the most common source of trauma) (**Macfarlane and Jeffcoate, 1997**) can lead to dorsal aspect ulcers (**Peters et al., 2007**).

- **Neuroarthropathy**

Charcot neuroarthropathy (CN) is a persistent, degenerative, painless arthropathy caused by sensory innervation disruption in the afflicted joint. The local blood supply is increased as a result of the autonomic nervous system impairment brought on by DM, and the resting blood flow is significantly higher than in a typical patient. When blood flow increases quickly, calcium dissolves, which triggers osteoclastic activity in the bone and damages it (**Rogers et al., 2011**). Another possibility is that the insensate joints will fracture and disintegrate as a result of repetitive mild stress. Osteolysis without control is caused by the production of pro-inflammatory cytokines in CN. Tumor necrosis factor-alpha and interleukin-1β are cytokines that increase nuclear factor-b receptor activator expression (RANKL), which in turn affects osteoclast maturation by inducing nuclear factor-b synthesis (**Madan and Pai, 2013**).

The stages and classification

There are five stages that can be used to categorise diabetic foot ulcers, which can aid with quicker diagnosis and treatment and a better understanding of the natural history (**Edmonds, M 2009**). Using the Wagner Ulcer Grade Classification System, ulcers are categorised according to the size of the wound and whether or not an infection is present. This grading system is frequently linked to diabetic foot ulcers caused by neuropathic, ischemic, and arterial aetiologies (**Kumar Amir C Jain, 2012**). The first stage of diabetic foot ulcers is the natural foot and can be performed by annual screening to determine the risk of foot or leg ulcers for all diabetes individuals who do not have neuropathic illness, ischemia, or deformity. Maintaining a sound foot care system and educating patients about wearing appropriate footwear are essential. When one or more risk indicators, such as neuropathy, deformity, or ischemia are discovered during the annual checkup and immediate medical intervention is necessary, particularly in the neuropathic foot, diabetic individuals are said to be in stage 2. Third-stage foot ulcers fall into two categories: neuropathic foot ulcers, which affect the foot and toes plantar, and neuroischemic foot ulcers, which typically affect the back of the heel and the tips of the toes and are brought on by wearing inappropriate footwear. It comprises vascular control, wound control, and control of relief. The foot is infected in the fourth stage, which is characterised by infections brought on by germs from the skin's surface, an unpleasant odour, purulent discharge, sinusitis, and possible exposure of the bones or tendons to infected ulcerated foot symptoms. It is vital to do an assessment of microbiological control in the administration of antibiotics to reduce the infection. It can advance to necrosis if not treated properly, and the last stage is necrotic foot, which can be either wet or dry. Wet necrosis progresses to neuropathic foot in a soft tissue infection caused by septic arthritis, whereas dry necrosis can evolve into neuroischaemic foot. The number of severe amputations in adult diabetes inpatients is reduced by the immediate and intensive treatment of diabetic foot ulcers.

Figure 1: The Wagner classification of diabetic foot ulcers. (Kumar Amir C Jain, 2012)

Risk Factors

Several causes raise the risk of developing foot ulcers which are smoking, high cholesterol level, overweight, high blood pressure, other complications of diabetes are the kidney condition, heart disease, and eye-related problem e.tc. Almost adults with diabetes have the potential for foot ulcers, and 12 % of adults have a history of foot ulcers (**Nelda et al., 2005**). It is generally recognized that the diabetic foot is most affected by three different pathologies: ischemia, inflammation, and neuropathy (**Wukich et al., 2013**).

To prevent more severe complications that can lead to foot amputation, it is, therefore, necessary to recognize patients that pose a high risk of developing a diabetic foot ulcer. Foot problems increased when the blood flowing to the legs and feet is reduced, neuropathy (nerve damage) and high blood glucose levels may also reduce the feeling of both legs and feet. The major risk factors for foot ulcers are previous amputation, past foot ulcer history, peripheral neuropathy, foot deformity, peripheral vascular disease, vision impairment, diabetic nephropathy (especially in dialysis patients), poor glycemic control, and cigarette smoking (**Boulton et al. 2005**).

Diagnosis

History and physical examination

A proper investigation should be performed for all diabetes patients. The duration of DM, symptoms of neuropathic and peripheral vascular disease, prior ulcers or amputations, and any other DM complications such as retinopathy or nephropathy should be included in a good background (**Lavery et al., 1998**). A complete history will help in assessing the severity and likelihood of foot ulceration. It is stated that foot examinations are effective in reducing the risk of amputations (**Mayfield et al., 2000**). The foot should be carefully inspected for defects, such as dry skin, fissures, deformities, and calluses. Ulcerations, conspicuous veins, and nail lesions must be looked out for. Changes in the temperature of the foot must be remembered. A rise in temperature may indicate inflammation (**Armstrong et al., 2007**), whereas a decrease may indicate ischemia.

Neurological testing

Caputo et al. (1994) suggested annual examination of all patients with diabetes with a nylon monofilament to diagnose peripheral neuropathy. Since metabolic neuropathies are more extreme distally, it is also possible to use a 128 Hz tuning fork to bilaterally monitor for vibratory sensation over the tip of the big toe. The pain sensation should be examined as well. In order to diagnose autonomic neuropathy, the variability of the heart rate (HRV) with deep breathing or orthostatic blood pressure is assessed (**Rogers and Bevilacqua, 2008**) and any drop or lack of HRV is considered the earliest indication of autonomic neuropathy in DMD (**Unger and Cole, 2007**). Specialized tests for sudomotor dysfunction are thermoregulatory sweat testing, quantitative sudomotor axon reflex testing, silicone impressions, sympathetic skin response (SSR) and quantitative direct and indirect axon reflex testing. In various combinations, these tests can be used to locate the autonomic dysfunction lesion (preganglionic or post-ganglionic) (**Illigens and Gibbons, 2009**).

Laboratory investigations

The standard procedure involves measuring the level of blood glucose and urine for glucose and ketones. Other studies, such as full blood count, blood urea, electrolytes and creatinine levels, should be controlled regularly. In order to measure the overall glycemic control of the patient, glycosylated hemoglobin (HbA1C) is important as HbA1c shows the best mean blood glucose level over previous weeks to months. Hepatic and renal function tests are required to monitor the metabolic status of the patient. To evaluate the presence and response of infections such as osteomyelitis to care, ESR can be performed. Since all wounds harbour microorganisms, regular wound cultures are not recommended. Deeper tissue cultures can, however, help differentiate the causative microorganisms in the presence of invasive infection (**Rabjohn et al., 2007**).

Imaging

The extent of the ulcer in the case of a diabetic foot, especially when it is covered by pus and slough, is difficult to assess. It is also difficult to assess the degree of deep infection, as the inflammatory response rubor is minimal in subfacial sepsis (**Naraynsingh et al., 2011**). X-rays are useful to ascertain the depth of foot ulceration and to determine the presence of bone infection or neuroarthropathy. CN radiographs may show bony erosions, fractures, subluxation/dislocation of multiple joints, osteosclerotic features, or united fractures (**Rajbhandari et al., 2002**). It is used to evaluate the extent of foot infection by revealing in the soft tissues, joints, and tendon sheaths the depth of ulceration, edema, and localized fluid collections. High specificity for osteomyelitis is demonstrated by positron emission tomography (**Madan and Pai, 2013**).

Other investigations

The extent of the vascular problem can be determined by the ankle-brachial index (ABI) or toe-brachial index (**Shin et al., 2000**). Values below 0.9 indicate an obstruction (**Doobay and Anand, 2005**) while tissue necrosis and a significant risk of amputation are associated with ABI less than 0.4 (**Reiber et al., 1992**). In patients with diabetes without any signs or symptoms of vascular insufficiency, ABI screening every 5 years is recommended. Pulse oximetry has also been reported to be as efficient as ABI and the sensitivity of the test would be increased if used with ABI (**Parameswaran et al., 2005**). The transcutaneous oxygen tension approach is a reliable predictor of skin perfusion, as the essential physiological determinant of ulcer healing is peri-wound cutaneous perfusion. TcPO2 has been associated with less than 20mmHgg of early wound healing failure (**Pecoraro et al., 1991**). Other investigations to detect vascular insufficiency include measuring absolute toe pressure, continuous-wave Doppler ultrasonography, duplex ultrasonography, pulse volume recordings, and angiography (CT, MRI, or contrast). Pedobarography is a foot pressure study and has also been used in diabetic foot research (**Lobmann et al., 2001**). In-shoe and barefoot peak plantar pressure measurement has also been suggested to assess foot at-risk and prevent ulcers (**Patry et al., 2013**).

Management

By ensuring glycemic control, proper perfusion, local wound care, and daily debridement, foot offloading, infection control by sufficient antibiotics, and comorbidity management, a multidisciplinary team preferably offers routine care for DFU. Patient education helps to reduce ulcers and their recurrence.

▪ Debridement

When the wound is clean, ulcers heal faster as the devitalized necrotic tissues inhibit the migration of cells and predispose them to infection and prohibit healing. Wound debridement can accelerate healing by removing dead necrotic tissue, particulate matter, or foreign materials and reducing the bacterial load (**Madan and Pai, 2013**). Using repeated 'piecemeal' debridement and herbal beverages, **Wong et al. (2001)** recorded an 87 % success rate in limb salvage. They said that radical debridement causes inadvertent damage to the vascularity of local tissue. Another technique is to completely excise the chronic ulcer and the underlying bony prominences and turn it into a new ulcer (**Armstrong et al., 2003**). The limiting factors of sharp debridement are inadvertent bleeding, poor pain control by the patient and the lack of any objective markers to differentiate impaired and healthy tissue to assess the degree of debridement (**Madan and Pai, 2013**).

▪ Dressings

Dressing materials used include saline-moistened (wet-to-dry) gauze dressings; moisture-retaining dressings that include physical and autolytic debridement respectively (hydrogels, hydrocolloids, hydrofibres, clear films, and alginates); and antiseptic dressings (silver dressings, cadexomer). New sophisticated dressings are being studied, such as Vulnamin© gel consisting of amino acids and hyaluronic acid are used along with elasto-compression has shown favorable results (**Abbruzzese et al., 2009**).

Offloading

Total contact cast (TCC), removable cast walkers, custom shoes, half-shoes, soft heel shoes, padded socks, and shoe inserts, wheelchairs, crutches, etc. were used for offloading the foot to prevent and treat the DFUs. The aim is to reduce the plantar pressure by redistributing it to a larger area, to prevent shear and friction, and to deal with the deformities. A randomized control trial compared the efficacy of a TCC, removable cast walker and half-shoe in patients with DFUs, which found TCC to be the most effective modality (**Armstrong et al., 2001**). A recent systematic analysis found that non-removable offloading devices (e.g. TCC) were more successful for ulcer healing than removable offloading devices (e.g. removable cast walker) (**Morona et al., 2013**).

Adjuvant therapy

Management strategies targeting the defective extracellular matrix (ECM) in DFUs include collagen or polylactic acid skin substitutes derived from rising autologous or allogeneic skin cells (**Rizzi et al., 2010**). They include a

cellular matrix such as DermagraftW (Shire Regenerative Medicine, Inc. La Jolla, California, United States) and Apligraf® (Novartis Pharma AG, Basel, Switzerland) or acellular like OasisW (Healthpoint, Ltd Fort Worth, Texas, United States) and Matriderm® (MedSkin Solutions Dr Suwelack AG, Germany) (**Lev-Tov et al., 2013, Jeon et al., 2013**). To promote these processes, they promote wound healing by "promoting revascularization, cellular migration, and repopulation of wound fields by providing appropriate scaffold material"(**Greaves et al., 2013**). They should not be used as a substitute for skin grafting or flap coverage, as stressed by **Brem et al., (2003).** The high cost, limited availability, risk of transmissible diseases, and immunological rejection limit their widespread use (**Rizzi et al., 2010**). Hyperbaric oxygen (HBO) is a useful adjunctive treatment for DFUs and is associated with decreases in amputation rates (**Liu et al., 2013**). In managing severe wounds, the beneficial effect of topical oxygen therapy has also been reported (**Kalliainen et al., 2003**). Low energy lasers have also been used as adjunctive therapy for DFUs (**Landau and Schattner, 2001**). They act by increasing microcirculation and enhancing the healing of the ischaemic DFU. Growth factors such as the recombinant human platelet-derived growth factor (rhPDGF) in the treatment of DFUs (**Hollinger et al., 2008**), topical platelets (**Scherer et al., 2012**), and platelet-rich plasma (**Villela and Santos, 2010**) were also used and showed favorable results.

Surgical management

Wound closure: With good granulation tissue, wound closure is attempted once the ulcer is clean. For small wounds, primary closure is possible; tissue loss may be covered with the aid of a skin graft, flap, or commercially available skin substitute. Split-thickness skin grafts over full-thickness grafts are preferred (**Younes et al., 2006**), the topical application of phenytoin before auto-grafting facilitated the development of granulation tissue and was found to increase graft uptake in large DFUs. **Yamaguchi et al., (2004)** used the combined method of treating DFUs to scrape the exposed bone until it bleeds and cover it with epidermal sheets collected from patient suction blisters. The authors reported a 100 % success rate with this technique. Muscle flap coverage for DFUs with exposed tendons, ligaments, or bones (**Attinge et al., 2002**). Flaps (for smaller wounds) may be either local or free flaps (for a large area). Latissimus dorsi, gracilis, or rectus abdominis are the commonly used free flaps. The limitations of standard flaps include donor site morbidity, flap shaping difficulties, and footwear interference (**Schirmer et al., 2013**).

Revascularization surgery: Patients with peripheral ischemia who have significant functional disability should undergo surgical revascularization if medical management fails. After control of infection in cases of ischaemic DFUs, **Brem et al., (2006)** recommended early revascularization. The procedures include open procedures for (bypass grafting or endarterectomy) or endovascular techniques (angioplasty with or without stent) (**Albayati and Shearman, 2013**). Good results have been reported for the use of percutaneous transluminal angioplasty with regard to angioplasty in terms of the low post-procedure amputation rate (5.2%) for the use of percutaneous transluminal angioplasty of the infrapopliteal artery (**Faglia et al., 2002**). However, a Cochrane study by **Berridge et al., (2013)**, between initial surgery and initial thrombolysis at one year, found no difference in limb rescue or death. The authors concluded that, in any case, the higher risk of complications related to thrombolysis must be balanced against the risk of surgery.

Amputation: Amputations are commonly used as a last resort treatment when other measures fail. Patients with DM account for around 40-60% of all the lower extremity amputations and most of them result from the deterioration of foot ulcers (**Apelqvist and Larsson, 2000**). **Schaper et al., (2013)** noted that patients with diabetes who have a foot infection are around 50 times more likely to be hospitalized and 150 times more likely than those without foot infections to undergo lower extremity amputation. The trade-offs between vascularity and limb length are required to determine the level of amputation. As a general principle, it is imperative to save as much limb length as possible. To assess the level of amputation, clinical examination, ABI and transcutaneous oxygen measurements (before and after oxygen inhalation) can be used, although these

transcutaneous oxygen measurements are preferred (**Canale and Beaty, 2008**). The frequently performed amputations for ischaemic DFUs are toe, Ray, transmetatarsal, tarsometatarsal (Lisfranc), midtarsal (Chopart), hindfoot and ankle (Pirogoff, Boyd, Syme's), and transtibial. To reduce the risk of infection and wound healing reported in patients with diabetes, Syme's two-stage amputation technique has been described (**Pinzur et al., 1991**). However, **Pinzur et al. (1995)** found that single-stage amputation of Syme was as effective as two-stage amputation in a randomized control trial. Along with Lisfranc and Chopart amputations, Achilles tendon tenectomy is favored to prevent equinus deformity. Tourniquet, thin skin flaps and muscle (myodesis) sutures to the bones are avoided (**Canale and Beaty, 2008**). The prevention of hematoma formation by meticulous hemostasis is required. Post-amputation, simple moistened gauze dressings are preferred. The most common psychiatric disease in amputees is depression and anxiety (**Singh et al., 2009**), and the decision to amputate a patient's limb must be made in consultation with the patient and with comprehensive counseling. Exostectomy, arthrodesis, and amputations are performed to manage complications such as CN. The indications for CN surgery are failed conservative management with deformity, joint instability, inflammation, and chronic ulceration (**Madan and Pai, 2013**). Usually, without surgery being needed, osteomyelitis responds to antibiotics. If required, however, the infected bone can be resected if the foot architecture is not affected (**Lipsky, 1997**).

Prevention

It is necessary to promote patient education and self-care practices, such as maintaining foot hygiene and nail care. After washing the feet gently with soap and water, the skin is kept moisturized with the application of topical moisturizers. The better avoidance of tougher steps such as hot soaks, heating pads, and topical agents such as hydrogen peroxide, iodine, and astringents become (**Armstrong and Lavery, 1998**). A direct correlation exists between glycemic control and the formation of ulcers (**Moss et al., 1992**). Neuropathic feet are colder and temperature variations between neuropathic and nonneuropathic feet of 2-7 ° C have been observed (**Mayfield et al., 1998**). Self-monitoring can also reduce the risk of ulceration (**Armstrong et al., 2007**). It is necessary to minimize smoking and alcohol consumption, and although the direct link between them and DFUs is weak (**Moss et al., 1992, Mayfield et al., 1998**). For foot at-risk, offloading and suitable footwear to relieve focal high-pressure areas is recommended. Other comorbidities should be treated, such as hypertension and hyperlipidemia, which are predisposed to vascular occlusion. Prevention of ulcer recurrence may also require corrective surgical interventions.

Factors Affecting Healing

Picwell et al., (2013) studied factors affecting the healing of diabetic foot ulcers, including ulcer location, diabetes duration, ulcer duration, heart failure presence, and peripheral arterial disease. The proximal location of the ulcer corresponded with the maximum healing time for plantar and non-planar ulcers, with no difference in healing times. **Sheehan et al., (2003)** noted that, after 4 weeks, the percentage change in the foot ulcer region can predict healing at the end of 12 weeks and can be used as an early indicator of treatment failure. Increased ulcer size and depth have been related to poor healing (**Margolis et al., 2000**).

Nurse interventions

Nursing intervention is a process by which nurses implement a nursing care plan that includes assessments and holistic patient care planning. This process involves a general awareness of everything that needs to be done to maximize the patient's health. Patients and their family members are supported by patient guidance, drug administration, hygiene, symptom control. To prevent re-occurrence or deterioration, a nursing intervention should also include educating the patients and giving instructions on their care and how to manage their health conditions. Nurses, dieticians, and other health care providers provide diabetic self-education. The treatment of diabetic foot ulcers requires nursing interventions because it helps to prevent more complications that can lead to amputation or foot infection. Foot self-care education plays an important role in the

prevention of foot complications in diabetic patients (**Singh et al., 2005**).

Goals of nursing intervention in diabetic foot care

Changes in patient care and health services are among the most significant challenges for nurses. Nurses are one of the main health organizations in the world, according to the World Health Organization, and they are involved in multiple levels of health. There are several reasons for the presence of nurses in the health care team, but in general, the four major goals are included health promotion, prevention of diseases, patients care, and simplify patients' compliance. Nurses may play a variety of roles to attain these objectives. For nurses, there are seven primary responsibilities, including 1. Health Care Providing, 2. Connector for care, 3. educator, 4. Expert consultant, 5. Leader, 6. Research member, 7. Supporting patients' rights (**Black et al., 1998**). To provide health services, nurses merge science and art and seek to eliminate physical, emotional, mental, social-cultural, and spiritual patient needs. Since patient care is the nurse's first responsibility to play an important role in diabetes care in developed countries, diabetes nursing is divided into many categories, including nurse practitioner, clinical nurse specialist, diabetes nurse, generalist nurse, and each of them has clear responsibilities. For instance, nurse practitioners focus on activities in the field of health promotion and disease prevention, including patient education and consultation (**Peimani et al., 2010**). There is an undeniable need to train nurse specialists in this field, with the growing prevalence of diabetes and its complications. To such an extent, the diabetic foot is so important that one of the main goals of Healthy People 2010 was to reduce the incidence of foot ulceration and amputation in diabetic patients. A 55 % reduction in amputations and a rise of almost 75 % in diabetic foot examinations were thus targeted (**Valente et al., 2004**, **US Department of Health and Human Services, 2010**).

Patient Education

Education of patients is a crucial nursing practice to avoid the recurrence of foot ulcers, with many patients lacking the education required to properly treat and care for their feet. Standard clinical practice is to provide patient education about the prevention of foot ulceration and amputation in diabetes patients (**Dorresteijn et al., 2012**). In order to minimize foot ulcers and amputations, diabetic foot ulcer patients need to be trained. Diabetic foot ulcer patients often have a loss of quality of life which can also lead to disability (**Bakker, 2005**). Patient education is an important nursing responsibility, and it should include an assessment of the effectiveness of patient teaching regarding common practices such as diabetic foot care (**Dorresteijn et al., 2012**). Nurses need to assess the ability of the patient to self-care, inform patients about how to care for their feet, healthy lifestyle, i.e. cessation of smoking, healthy diet, and exercise (**Dorresteijn J. et al., 2010**). Patients' education can be done by giving lectures, handbooks, telephone follow-up, and group exercise.

Self-care

Patients with diabetic foot ulcers need to continue self-care and management of their foot ulcers by controlling their diets, weight, glucose level, foot extermination, medication enforcement, proper footwear, physically active and proper wound dressing, to reduce or avoid infection, recurrence, and amputation. During their hospital stay, nurses need to inform DMF patients on the significance of self-care monitoring, and total commitment to both of these would minimize more complications and improve the quality of life. Research has shown that patients with diabetes frequently do not participate in consistent foot self-care (**Chin and Huang, 2013**). Nurses teach diabetic foot patients how to clean, dress their wounds, examine their feet, and determine what to wear.

Healthy lifestyle

In the prevention of diabetic foot ulcers, educating the patient about a healthy lifestyle is very important. This healthy lifestyle consists of a healthy diet, exercise, smoking avoidance, etc. Diabetic foot ulcer patients are educated on a healthy diet; hyperglycemia can cause tissue damage that can lead to ischemia that can lead to impaired healing of the wound. Nutrition therapy helps to promote wound healing, patients should be encouraged to eat a balanced diet meal and certain supplement recommended by a physician can also be used to meet the

body requirement (**Grieger, 2009**). Body-weight should be controlled by patients, it helps with good quality of life, and it can be achieved by eating and exercising healthily. To improve the health of a diabetic patient, education about exercise is also essential. Patients with diabetic foot ulcers are educated about the significance of regular physical exercise, helping patients lose weight, and control glycemia (**Physical Activity Guidelines Advisory Committee, 2008**). Smoking harms wound healing; cigarette smoke contains the toxins that are associated with impaired wound healing. Smoking reduces blood flow, harmful to tissues, nervous system, lungs, the risk of infection, slow healing. Diabetic foot ulcer patients should be educated on the importance of cessation of smoking, what are the things that cause a relapse, learn how to quit, and where they can get the assistance needed in quitting smoking. Nurses should also follow-up on patients who are willing to quit smoking and give them the resources needed to cope with wound healing to quit smoking.

Nurses' role in the care

Examination and screening

Peripheral neuropathy, peripheral vascular disease, and infection are three key factors that may lead to gangrene and amputation in diabetic foot ulcers (**Browne and Sibbald, 1999**). Peripheral neuropathy, however, is primarily responsible for more than 80 % of diabetic patients' foot ulcers. This is important not only for the neurological examination as the first criterion for screening patients at risk for foot ulcers (**Tabatabaei-Malazy et al., 2010**), but also indirectly emphasizes the role of the nurse in performing the monofilament diabetic foot examination and in coordination with other members of the diabetic foot team. In the early stages of care and treatment, nurses specialized in foot care are involved (**Azizi, 2005**). The role of nurses in diabetic foot care includes foot examination, wound dressing (**Seaman, 2005**), as well as promoting appropriate care and daily follow-up visits for patients and families (**Bielby, 2006, Fletcher, 2006**). Early detection of diabetic foot problems, identification of those at risk, and planning to reduce the risk of ulcers are the primary objectives of screening (**Yetzer, 2004**). All visits should include a diabetic foot examination. To screen patients at high risk, nurses should ask patients to remove their shoes and socks (**O'Brien et al., 2003**) and then examine their feet, and report to other members of the multidisciplinary diabetic foot team (**Williams, 2001**). Nurses can achieve vascular status with an ankle-brachial index (ABI) and toe pressure in a diabetic foot specialty clinic. Also, the pedographic system and thermometer are used to assess foot sole pressure and foot temperature (**Frykberg, 2005**) to determine the severity of foot problems and the risk of diabetic ulcers.

Nurse cooperation in the diabetic foot treatment

Complementary care, such as selection and proper dressing according to the form of ulcers, should be another part of the duties that a nurse provides to produce excellent diabetic foot care. The dressing is necessary depending on the type of wound that is wet or dry, as dressings help to debride and decrease the number of wounds while keeping the wound clean and maintaining the wound moisture, help to debridement and reduce the number of bacteria (**Armstrong and Lavery, 2005**). It is necessary to improve the awareness and knowledge of nurses in this field concerning the variety of novel dressings.

Nursing role in diabetic foot care at home

The follow-up of diabetic patients at specified intervals is part of the care plan that should first be considered. To be evaluated annually for diagnostic and thorough foot care, all diabetics should also be referred to a diabetes clinic (**American Diabetes Association, 2010**). Daily foot care is difficult for some diabetic patients, especially patients with limited vision due to diabetes and other chronic diseases since they have been unable to evaluate their feet. In combination with delayed wound healing, peripheral vascular disease, decreased foot sensation causes difficulties in foot care. Nurses should evaluate these complications in both hospitals and home visits. Diabetic foot nurses should have completed the initial clinical care list and examined the limb movement, health, moisture, color, temperature, edema, pain, and sensation of the foot while examining the patient's feet in the clinic or at home (**Black et al., 1998**) **Table 1**.

Table 1: The basic principles of foot care in the clinic and home visit

• To examine feet daily for discoloration, swelling, skin cracks, pain or numbness
• Use the self-help methods to help foot examination such as using mirrors
• Foot hygiene (daily washing, followed by drying feet carefully, especially between the fingers)
• Controlling water temperature before washing foot
• To avoid going barefoot or wearing shoes without socks
• To choose shoes that are precisely in size. The best time for buying shoes is in the afternoon.
• Cutting the fingernails directly
• To avoid manipulation of foot lesions such as corn
• To keep wet the dry surfaces of the foot by moisturizing creams except between the fingers.
• To ask for help if the reduction of the visual acuity.

Nursing role in the rehabilitation

One of the responsibilities of nurses is to help the movement of patients with diabetic foot ulcers. This is particularly important for patients who have lost their feet. Patients should be encouraged and trained to use assistive devices by nurses. Nurses can then identify various types of devices and their applications to introduce patients and maintain their mobility based on patient conditions. For example, a diabetic foot nurse's duties in this area include the introduction, training, and participation of patients in the use of devices such as canes, walkers, and wheelchairs (which completely remove the pressure on the limb), along with aids such as shoes, boots, Scottish stone, full contact plaster, plaster walker, are an effective method for removing foot pressure (**Armstrong et al., 2005**).

Conclusion

One of the health system concerns is the diabetic foot as the most common cause of hospitalization in diabetic patients. Daily foot checks by the patient and the caregiver may supplement annual foot examinations by a health care provider (or more frequently, if indicated by the Lower Extremity Amputation Prevention score) to improve early recognition and intervention in the prevention of further complications. In this regard, as members of the diabetes care team, nurses not only need to play their role in health care, public education, management of the health system, patient care, and improving the quality of life, but they also need to participate in special training to use the latest diabetic foot care instructions to provide effective services to promote the health of diabetic patients.

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