Original article

Challenges of dealing diabetic foot and step wise surgical management

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Abstract

Soft tissue reconstruction of the diabetic foot is a challenge for the perioperative team. This study aims to describe a group of methods for the management of diabetic foot ulcers in order to reduce deformity and salvage the lower limb. This study emphasizes the appropriate timing and staging of surgery, discusses the most common plastic surgery techniques, and underscores the importance of a team approach in the management of diabetic foot wounds. A group of different advanced methods for the management of Diabetic foot such as sharp debridement of ulcers, application of vacuum therapy, and other forms of reconstructive plastic surgical procedures were used. Data collection was done in Z. H. Sikder Womens Medical College Hospital where the treatments were given. The study period was Jan 2018 to July 2019. Thirty-four patients with type 2 and type 1 diabetes mellitus were enrolled in the current study. Females (61.05%) and males (38.95%) with different stages of diabetic ulcer and related problem underwent treatment within this time frame. They underwent different methods of surgical management: debridement (12%), vacuum therapy (24.06%), amputation (4.04%), skin grafting (38.00%) and flap reconstruction (21%). The outcome is satisfactory and offer less hospital stay. Using advanced surgical wound management including reconstructive plastic surgical procedures; it was possible to reduce the hospital stay, the rate of high amputations of the lower limb and the deformity.

Keywords: Diabetes, Diabetic foot, Skin graft

Introduction

Diabetic foot is a disease complex that can develop in the skin, muscles, or bones of the foot as a result of the nerve damage, poor circulation and/or infection that is associated with diabetes. It can define also any foot pathology that result from diabetes or its long – term results.[5] Diabetes is the most common medical condition leading to lower limb amputation and 85% of amputations are preceded by foot ulcers that fail to heal. Diabetic foot is one of the most significant and devastating complications of diabetes, and is defined as a foot affected by ulceration that is associated with neuropathy and/or peripheral arterial disease of the lower limb in a patient with diabetes. Many studies have reported that foot ulcers precede approximately 85% of all amputations performed in diabetic patients.[5] The risk of foot ulceration and limb amputation increases with age and the duration of diabetes.[4,5] The prevention of diabetic foot is crucial, considering the negative impact on a patient's quality of life and the associated economic burden on the healthcare system.[6] Diabetic foot ulceration is a major health problem and its management involves a multidisciplinary approach.

Pathogenesis

The most significant risk factors for foot ulceration are diabetic neuropathy, peripheral arterial disease, and consequent traumas of the foot.[2] Peripheral sensory neuropathy is still poorly understood, there seem to be multiple mechanisms involved, including the formation of advanced glycosylated end products and diacylglycerol, oxidative stress, and activation of protein kinase.[7,8] Nerve damage in diabetes affects the motor, sensory, and autonomic fibers. Motor neuropathy causes muscle weakness, atrophy, and paresis. Autonomic dysfunction causes vasodilation and decreased sweating,[8] resulting in a loss of skin integrity, providing a site vulnerable to microbial infection. The majority of foot ulcers are of mixed etiology (neuroischemic), particularly in older patients. In patients with peripheral diabetic neuropathy, loss of sensation in the feet leads to repetitive minor injuries from internal (calluses, nails, foot deformities) or external causes (shoes, burns, foreign bodies) that are

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undetected at the time and may consequently lead to foot ulceration.

Evaluation

Foot ulcer evaluation should include assessment of neurological status, vascular status, and evaluation of the wound itself. Neurological status can be checked by using the Semmes-Weinstein monofilaments to determine whether the patient has "protective sensation," which means determining whether the patient is sensate to the 10-g monofilament. Another useful instrument is the 128 C tuning fork, which can be used to determine whether a patient's vibratory sensation is intact by checking at the ankle and first metatarsal-phalangeal joints to exclude metabolic neuropathy.[3,8] Vascular assessment is important and assessment done by checking pedal pulses, dorsalis pedis on the dorsum of the foot, and the posterior tibial pulse behind the medial malleolus, as well as capillary filling time to the digits. Further assessment is done by Doppler. Ulcer evaluation should include documentation of the wound's location, size, shape, depth, base, and border. X-rays should be ordered on all deep or infected wounds, but magnetic resonance imaging often is more useful because it is more sensitive in detecting osteomyelitis and deep abscesses.[3]

Classification of Ulcer: Classification of ulcerations can facilitate a logical approach to treatment and aid in the prediction of outcome. Several wound classification systems have been created, based on parameters such as extent of infection, neuropathy, ischemia, depth or extent of tissue loss, and location.[9] The most widely accepted classification system for diabetic foot ulcers and lesions is the Wagner ulcer classification system, which is based on the depth of penetration, the presence of osteomyelitis or gangrene, and the extent of tissue necrosis (Table 1)

Table 1: Adapted with permission from Wagner FW Jr. The diabetic foot

	Wagner Ulcer Classification System
Grade	Lesion
0	No open lesions; may have deformity or cellulitis
1	Superficial diabetic ulcer (partial or full thickness)
2	Ulcer extension to ligament, tendon, joint capsule, or deep fascia without abscess or osteomyelitis
3	Deep ulcer with abscess, osteomyelitis, or joint sepsis
4	Gangrene localized to portion of forefoot or heel
5	Extensive gangrenous involvement of the entire foot

***Source: Orthopedics 1987;10:163-72.**

Treatment

The primary goal in the treatment of diabetic foot ulcers is to obtain wound closure. Management of the foot ulcer is largely determined by its severity (grade) and vascularity, and the presence of infection. A systematic approach to treatment should be taken for all diabetic foot lesions. A multidisciplinary approach should be employed because of the multifaceted nature of foot ulcers and the numerous comorbidities. This approach has demonstrated significant improvements in outcomes, including reduction in the incidence of major amputation.[5,6]

Debridement: Mechanical debridement is used in the management of surgical wounds and venous leg ulcers. Enzymatic debridement involves debridement of necrotic tissue by topical enzymes such as streptokinases, trypsin, papain, fibrinolysin- DNase, collagenase, papainurea and streptodornase. Maggot debridement is considered a biological debridement option using maggots or fly larva that are raised in a sterile environment. The most commonly used fly is Lucilia sericata. They can be used in humans when conventional treatments have failed. Maggots are applied to the wound and wrapped with secondary dressing. Larvae secrete is a powerful autolytic enzyme that liquefies necrotic tissue, stimulates the healing process and destroys bacterial biofilms.[10]

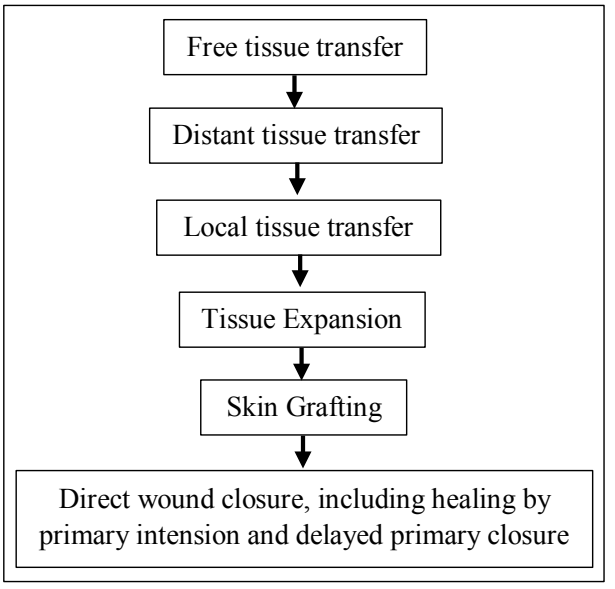
Infection control: For mild (superficial) Diabetic Foot Ulcer infections, patients who have not recently received antibiotics may advise one to two weeks antibiotic which is sufficient to control infection. Topical antimicrobial therapy may be used for some mild superficial infections, for moderate and severe DFU infections, an empiric antibiotic regimen with activity against Gram-positive and Gram-negative organisms, including anaerobic bacteria, must be offered. But when culture and sensitivity results are available, empiric therapy should be switched to definitive appropriate treatment.[11] Severe DFU infection should be treated initially with parenteral antibiotics. For osteomyelitis, at least four to six weeks of parenteral antibiotic agents with adequate penetration to bone is required.

Wound dressings: Wet-to-dry or simple saline dressings, Silver-impregnated dressings are available in various formulations and have been associated with antimicrobial properties, Polyurethane films often form the outer layer of other dressings such as hydrocolloids, foams, hydrogel sheets and composite dressings. The vapour-permeable films allow the diffusion of gases and water vapour, which help to maintain a moist wound-healing environment.[12] Hydrogel dressings consist of cross-linked insoluble starch or carboxy-methylcellulose polymers and up to 96% water. Hydrogels donate fluid to dry necrotic and slough wounds and promote autolysis and debridement by rehydrating the wound, Alginate dressings (calcium alginate and calcium sodium alginate) are bacteriostatic, haemostatic and highly absorbent with the ability to absorb approximately 15 to 20 times their

own weight in wound fluid. Negative pressure wound therapy (NPWT) has emerged as an effective treatment for complex wounds.[13]

Off-loading: Pressure relief under weight-bearing areas is important to heal plantar DFUs. Off-loading devices reduce pressure at the site of a wound by redistributing loading forces across the plantar surface of the foot and, in some cases, the leg as well, thereby preventing isolated excessive force at the DFU site. An ideal off-loading device must be patient compliant, easy to apply, cost-effective, effective in wound healing and comfortable for ambulation. These include total contact casts (TCCs), walker air casts and removable cast walkers (RCWs), crutch-assisted walking, therapeutic shoes and non-removable knee-high devices with an appropriate foot–device interface.[7,8,13]

Surgery: Surgical therapies can range and selection is based on the needs of the patient, stability of the joint and the anatomical location involved as well as patient specific characteristics.



Materials and Methods

The study was a prospective observational study. The study was conducted in Department of Surgery, Z.H. Sikder Women's Medical College Hospital , Dhaka, over a period of Jan 2018 to July 2019. A total of 34 cases who fulfilled the enrolment criteria were selected from study population. Purposive sampling was done in this study. Data were collected from the selected patients using a pre-designed structured questionnaire. The management process was divided into 5 steps: patient evaluation, wound preparation, improving vascularity, surgery and dressing, and rehabilitation. Patient management included assessment, evaluation of vascularity by palpation and/or hand-held Doppler, and an osteomyelitis, wound preparation, debridement and negative-pressure wound therapy were performed. Lastly Surgery and dressing were performed depending on the indications. Rehabilitation was started after complete wound healing.

Enrolment criteria

Inclusion criteria

Patients with following characteristics were included:

1. Patients of any age and sex with DM and foot ulcer
2. Type I and II Diabetes Mellitus
3. Foot ulcer due to Atherosclerosis, Neurotropic ulcer, repeated trauma, chronic non healing ulcer, Ulcer complicated due to uncontrolled diabetes.
4. Patients who comply with the protocol and come for follow up.

Exclusion criteria

1. Patients with other comorbidity who is not fit for surgery.
2. Diabetic Patient with deep burn or Malignancy in foot
3. Diabetic Patients with poly trauma and life threatening condition
4. Patient unwilling to incorporate with the protocol
5. Lost to follow up

Results and Discussion:

Total DFU patients' proportion among all outdoor Diabetic patients with foot deformity, injury, ulcer is 0.25%. Robert M shows annual incidence rate of foot ulcers was 0.34% (range 0.22–1.08%). UK National Diabetes Audit, which reports on the proportion of individuals with diabetes receiving care according to national recommendations, reported that 87% of patients received a foot examination.

Table 2: Demographic Characteristics of patient with DFU

Gender	Frequency	Percentage
Male	13	39
Female	21	61

This figure compares favorably with the 56% found in our study. One possible explanation for the difference might be a more complete registration in the UK12. The incidence of Diabetic foot ulcer is usually common among male sex 51.0% and Age (years) 65.8 ± 14.4,[12] but in our study it was more common among female (61%) where male incidence found 39%. Cheng, Xuyen shows in another article about patients consisted of 168 males and 106 females where n = 274.[26]

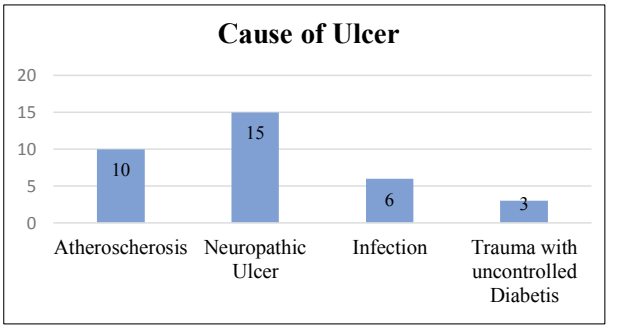


Figure 1: Diagram shows cause of Ulcer

An important observation in the present study is that despite the relatively favourable estimates of ulcer incidence, identifiable risk factors were quite prevalent. In line with the overall lower rates of actual ulceration, these numbers compare relatively favourably with previous studies. Absent pedal pulsations 7652 (14.6%), Sensory neuropathy 9075 (17.3%), Callus/pressure marks 5295 (10.1%), Any abnormalities 16,573 (31.6 %) where n = 52,524.[12]

Different causative factors are identified such as neurotrophic ulcer is the commonest and 15 patients (44.11%) were recorded. Atherosclerosis is the second commonest cause which is ten (29.4%). Other causative factors were infection (six patients) and trauma (3).

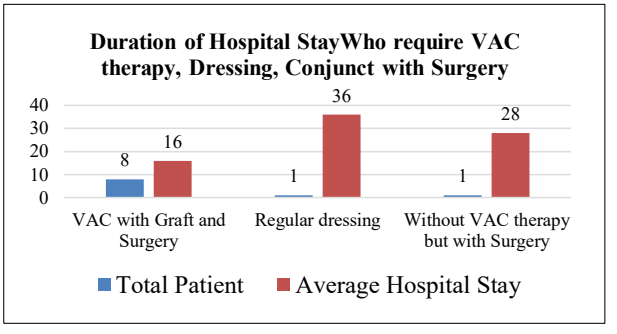


Figure 2: Bar diagram shows duration of hospital stay od DM patients who require VAC , Long time Dressing, VAC and other adjunct along with surgery

Among 34 patients 14 patients require early surgery and managed to send home within 7 days but 8 individuals with primary care setting foot ulceration managed with Vacuum Assisted Closure along with graft and Surgery. One Patient managed with VAC therapy along with surgery required to stay 16 days at hospital. In comparison one patient with diabetic foot that managed only by dressing and allow secondary healing. He required long hospital stay about 36 days. One patient initial management with dressing and then surgical intervention also required 28 days of hospital stay. Muller et al reported a mean annual ulcer incidence of 2.1% and average hospital stay is 15 days. Similarly, de Sonnaville et al reported average treatment time is 22 days.[14] Alexiadou also mention that majority (60–80%) of foot ulcers will heal, while 10–15% of them will remain active, and 5–24% of them will finally lead to limb amputation within a period of 6–18 months after the first evaluation. Neuropathic wounds are more likely to heal over a period of 20 weeks.[2]

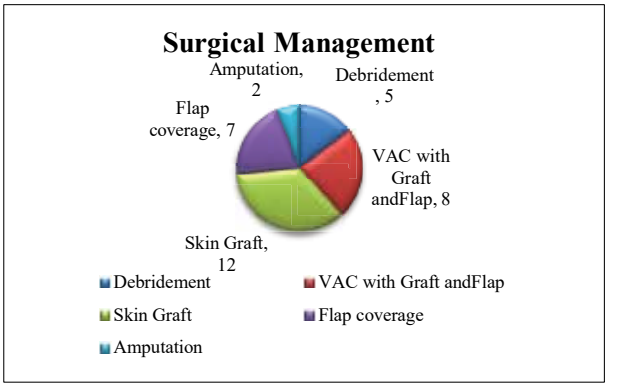


Figure 3: Pie chart show the option of surgical options

Figure 3 demonstrated the surgical management protocol where majority of patients underwent simple debridement, VAC, Dressing. Seven patients (20.5%) required flap coverage whereas 12 (35.29%) patients needed skin graft. Severely gangrenous foot also required amputation and only 2 patients managed in such a way. Regarding surgical option and amputation, 204 local random flap procedures was done by Cristal L.[14] Based on current available evidence found in this systematic review, local random flaps demonstrated a relatively high success rate when utilized for the definitive closure of diabetic foot wounds.[14] Another report shows majority patients require different level amputation 48% and they used 16.1% local flap, 15% patients managed by free flap. A large number of patients also managed by skin graft. 11.4% patients wound covered but skin graft and 6.4% patients required skin graft along with Acellular dermal matrix.[26]

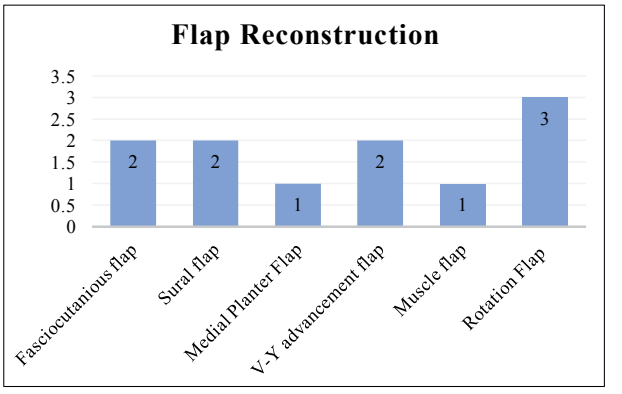


Figure 4: Bar diagram shows different flap surgery

Total eleven patients with foot ulcer require flap surgery. Different types of flap were used to reconstruct the foot defects. Forefoot wound managed with rotation flap in 3 cases and two forefoot wound by V-Y advancement flap. In case of midfoot wound muscle flap (1) and fasciocutanious flap was the option of coverage. Sural flap and Medial plaster flap used for hindfoot wound. It

has been observed that step wise management offered most benefit to the patients and the ulcer covered with flap had got good tissue coverage which minimal recurrence. Mark W. Clemens describe different closure techniques include allowing the wound to heal by secondary intention or by closing it with (1) delayed primary closure, (2) skin graft, (3) local flap(s), (4) pedicled flap(s), (5) free flap.[27] Use of any flap requires an accurate assessment of the blood flow. For local flaps, there should be a Dopplerable perforator close to the base of the flap. For pedicled flaps, the dominant pedicle to the flap should be open. They usually consist of skin and the underlying fat or skin, fat, and the underlying fascia. It is important to carefully preplan the flap by first accurately determining the size of the defect that needs to be covered after debridement.[14,27]

Patient 1

Fig 5: Forefoot wound

Fig 6: After application of VAC

Fig 7: After STSG

Patient 2

Fig 8: Ulcer over lateral planter arch

Fig 9: Rotation Flap

Fig 10: After flap coverage

Patient 3

Fig 11: Hindfoot wound

Fig 12: Sural flap

Fig 13: 3 months after sural flap

Conclusion

Treating diabetic foot ulcers and gangrene can only be done effectively by using a team approach. The wound needs to be accurately assessed, prepared to salvage the limb and if required need amputation to save the patient's life. Allow healing by secondary intention can be attempted only for small defects without bone exposure. This modality induces granulation and epithelialization by the dressing treatment. As diabetic ulcers do not respond well to ordinary dressings, supplementary materials such as VAC or other adjunct should be added. Although grafted skin is less durable than a flap, but it is good option to cover some areas. All this options of management required long time treatment and hospital stay. The main advantage of flap surgery is that it provides durability with sufficient amount of tissue. For this reason, flap coverage is effective in areas with bone

exposure and in weight-bearing areas. Areas with tendon exposure where a skin graft cannot be used are also good candidates for flap coverage. So salvation of limb is the motto and management option should be consider as per requirement and patients condition.

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