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Case Series

Study of various reconstructive modalities in management of diabetic foots

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ABSTRACT

Diabetic foot ulceration is the most common complication seen in the patient with diabetes with lifetime risk of a foot ulcer as high as 25%, which is the most critical risk factor for lower-extremity amputation. In this study, we have reviewed our experiences with diabetic foot and established an algorithm for surgical reconstruction of diabetic foot. We studied 50 patients and clinical findings based on predisposing factors, complications, treatment and sequalae were studied, analysed and discussed. Split thickness skin graft, local or distant flap surgery was planned according to patient factors. The best possible option was chosen to cover the defect. Patient was monitored in post- operative period for any signs of flap failure and appropriate measures were taken, if required to treat such complications. Out of 50 cases studied, 29 (58%) patients were managed with split thickness skin graft. 14 (28%) patients were managed with flap surgery. Various post operative complications were managed accordingly. The choice of reconstructive modality in the management of diabetic foot ulcers should be based on the specific characteristics of the wound and the patient's overall condition. Skin grafts are suitable for larger wounds over dorsum of foot and wounds over non weight bearing area of sole, while flaps provide stable, supple, durable and sensate coverage. To prevent recurrence, well-padded flap with sensate coverage is needed. Ultimately, the selection of the appropriate reconstructive modality should be made to ensure the best possible outcome for the patients.

Keywords: Diabetic foot, Foot reconstructive surgery, Diabetic foot complications, Skin graft, Local flaps, Free flaps

INTRODUCTION

Diabetic foot ulceration is the most common complication seen in the patient with diabetes.[1] The lifetime risk of a foot ulcer for patients with diabetes may be as high as 25%, and it is the most critical risk factor for lower-extremity amputation.[2,3] Treatment of diabetic foot ulcers requires management of a number of systemic and local factors.[4-7] The most common cause of hospitalization of patients with diabetes is soft- tissue and bone infections involving the foot.[8,9] The main predisposing factors for the development of diabetic foot infections are macroangiopathy, microangiopathy, peripheral neuropathy and the altered immunologic response of patients with diabetes.[10] Presence of infection in the diabetic foot is associated with substantial morbidity and mortality.[11] Diabetic foot ulcers with infections need to be detected at an early stage to avoid major limb amputations and prevent further complications. Wounds with infection alter the normal healing process by disrupting the healing and prolonging the inflammatory phase.[12] Many clinicians tend to treat the diabetic foot by conservative means because of a lack of experience with care for patients with diabetic foot. Although many patients with diabetic foot are hospitalized and treated with conservative means, the role of surgical management in the form of skin graft and flap is often underestimated and diabetic foot can lead to

sepsis. Sepsis of the limb can become a life-threatening event that may result in amputation of the lower extremity. It has been investigated by various researchers that sepsis increases the patients' risk for above-ankle amputation, as well as increases the burden of cost, as these patients are subjected to prolonged conservative therapy.[13,15]

Early aggressive surgical intervention may prevent eventual limb loss and the need for above-ankle amputation, decrease the total cost to treat the patient, and may restore full ambulation earlier.[15] In other studies, any amputation, regardless of the level, was considered a treatment failure. Because limited amputation may restore the ability to function, debridement and limited amputation are part of the therapy. The authors use the end point of above-ankle amputation to describe treatment failure, as past studies have also done. In this study, we have reviewed their experiences with diabetic foot and established an algorithm for surgical reconstruction of diabetic foot.[13]

Figure 1 (A and B): Anterolateral thigh free flap pre and post operative photograph.

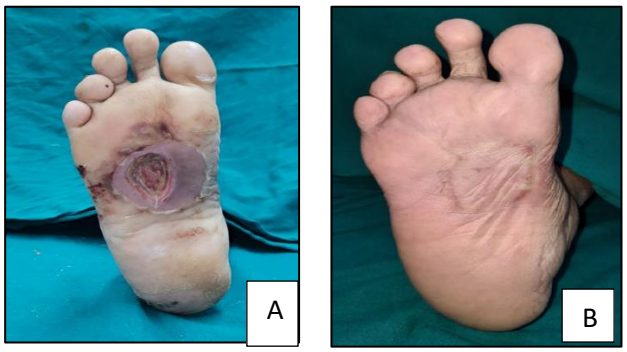

Figure 2 (A and B): Medial plantar artery flap pre and post operative photograph.

CASE SERIES

we studied 50 patients During the period of January 2023 to March 2024, and clinical findings were recorded on basis of predisposing factors, complications, treatment and sequalae which were studied, analysed and discussed. Patients who presented directly to the department or were referred from other department or hospital with abscess, cellulitis, raw area and/or defect over foot with history of diabetes or newly diagnosed as incidental case of diabetes were included in the study. Patients with more than 18 years of age having existing or newly diagnosed diabetes mellitus and suffering from foot ulcers, infections and/or toe gangrene were included in the study. Patients with foot infections without diabetes mellitus by any other etiology or patients with raw area or defect extending to leg complicated with diabetes and whose treatment could not be completed due to non-compliance were excluded from the study.

Figure 3 (A and B): Split thickness skin graft pre and post operative photo.

Routine investigations (blood investigations, urine examination, X-ray chest and foot) and special investigations like HbA1c, arterial color doppler, etc. were done as per requirement. All patients were put on 6 hourly sliding insulin scale and diabetic control was achieved, appropriate antibiotic coverage was given as per culture and sensitivity report. Local wound care and surgical debridement was done before planning of any definitive reconstructive surgery. Local or distant flap surgery was planned in the patients who had the weight bearing area affected and having favorable arterial doppler study.

Split thickness skin grafting was done in the patients who had raw area over dorsum of foot or non-weight bearing area of the plantar foot, in the patient who had poor diabetic control or unfavorable arterial doppler study of the affected limb. Patients who were not willing for flap surgery were also included in this group. Patients who had osteomyelitic changes in phalanx/metatarsal head, toe amputation with toe fillet flap coverage was done and if raw area was present along with it then skin grafting was done. First dressing was done at 48 hours post-surgery and then at 72 hours interval. Donor site for skin graft was checked and dressed at 3 weeks post operatively when needed. In treatment planning, choice

of flap was based on the site and size of the defect and available loco regional and distant flaps. The best possible option was chosen to cover the defect. Patient were monitored in post-operative period for any signs of flap failure and appropriate measures were taken, if required to treat such complications. When free flap was done, intraoperatively all patients were operated as a 2-team approach. Senior surgeon harvested the flaps and the assistant team either debrided or dissected vessel at the recipient site simultaneously. In patients who usually presented late or had extensive biofilm formation, we preferred to stage the procedure in 2 stages. 1st stage was debridement and vessel identification, and after 3 days of 1st stage we performed the final free flap in 2nd stage.

All microsurgical anastomosis were performed under loupe magnification (4X) with PROLENE 7/0 or 8/0 sutures as per vessel diameter. 2500 units of bolus Heparin injection was given intravenously after completing arterial anastomosis. Due care was taken to maintain optimum temperature inside operative room. All patients were given stabilizing slab with loose yet thick dressing to immobilize the recipient area and keep flap warm.

Window was made in dressing for flap monitoring. Post operatively the recipient area was kept elevated and warm. Hourly monitoring in the first 24 hours, 2 hourly on day 2 and then 4 hourly from 3rd day onwards was done with standard clinical parameters as well as with the hand held doppler. All patients were monitored to maintain systolic blood pressure between 100-140 mmHg and urine output above 30 ml/hour. Antibiotics were given as per culture reports.

All patients were started on continuous IV infusion of 5000 units Heparin in 500 ml of normal saline at 20 ml/hour for 5 days during postoperative period and changed to oral tablet aspirin 75 mg once a day after 5th day. All patients were started orally as per clinical condition but usually 6 hours after surgery. Blood investigations were repeated on post-operative day 1 and then as and when required and blood transfusion was given if hemoglobin fall was significant or below 9 gm%. Strict immobilization was maintained till flap stabilization. We usually preferred corrugated drain under flap to prevent hematoma under flap which was removed at 1st postoperative dressing.

All patients were immobilized using below knee plaster of Paris slab and proper limb elevation given. Patients who were discharged from the ward were followed up every week for first month, then every 10 days for 2nd month, then every two weeks for 3rd month. Physiotherapy was started as soon as the skin graft or flap settled to prevent stiffness and early rehabilitation. On follow up they were analyzed in regards to local site or donor site complication, ambulation, and routine daily activity.

Out Of 50 cases studied, most of the diabetic patients with foot lesions were in the age group of 51-60 years (30%) followed by 41-50 years (28%). The youngest was 37 years and the oldest was 93 years. 34 (68%) were male patients and 16 (32%) cases were female patients with male: female ratio of 2.12:1. The most common presentation as seen in table 1 was ulcer totaling 27 (54%) cases while most common site of lesion as seen in Table 2 was dorsum of foot which was in about 24 patients (48%), followed by sole 15 (30%), toes 11 (22%) and heel in 10 (20%) cases. In this study many patients had more than one sites were involved on the foot, in which toes and dorsum of foot was involved in 7 (14%) cases while toes and sole were involved in 3 (6%) cases. 17 patients (34%) had history of trauma. Most patients 20 (40%) had diabetes for about 6-10 years. Newly diagnosed incidental cases were 9 (18%). 6(12%) patients had history of both smoking as well as tobacco chewing. 33 (66%) patients presented with neuropathy. Ischemia was seen in 25 (50%) patients and there was osteomyelitis in 9 (18%) patients. In arterial color doppler study, 14 (28%) patients had atherosclerotic vessels, 20 (40%) patients had biphasic flow with patchy atherosclerosis and remaining 16 (32%) patients had triphasic blood flow. Mean HbA1c was 9.362. 29 (58%) patients were managed with split thickness skin graft. 14 (28%) patients were managed with flap surgery, among which 7 were local flaps (including 3 cases of medial plantar artery flap) and 7 free flaps (5 cases of anterolateral thigh free flap and 2 cases of radial forearm free flap) as shown in table 3. 17 (34%) cases had complications. Among which total flap necrosis was present in 3 (6%) cases and 1 (2%) case had partial flap necrosis, all of them were Anterolateral thigh free flaps. Total graft loss was noted in 1 (2%) case, which was managed by redo split thickness skin graft and partial graft loss occurred in 8 (16%) cases as shown in table 4. Average hospital stay was 25 days.

Table 1: Clinical presentation of diabetic foot.

Clinical presentation	No. of patients	Percentage
Ulcer	27	54
Cellulitis	9	18
Abscess	3	6
Gangrene	7	14
Neuropathic ulcer	4	8

Table 2: Site of lesion.

Site of lesion	No. of Patients	Percentage
Toes	11	22
Heel	10	20
Dorsum of foot	24	48
Sole	15	30

Table 3: Surgical management.

Operative procedure		No. of patients	Percentage
Amputation+toe fillet flap/split thickness skin graft		7	14
Split thickness skin graft		29	58
Local flap	Local advancement flap	2	4
	Rotation advancement flap	1	2
	Transposition flap	1	2
	Medial plantar artery flap	3	6
Free flap	Anterolateral thigh free flap	5	10
	Radial forearm free flap	2	4

Table 4: Post operative complications.

Complication	No. of patients	Percentage
Total flap necrosis	3	6
Partial flap necrosis	1	2
Total graft loss	1	2
Partial graft loss	8	16
Suture dehiscence	4	8

DISCUSSION

Lower extremity complications remain among the most common reasons for hospitalization in people with diabetes. Approximately one in four people with diabetes will develop a foot ulcer. The recent increase in success of microvascular free tissue transfer in diabetic patients has allowed for better quality of life and extension of the survival rate. However, the same cannot not be said for patients with diabetic foot with poor vascular supply where amputation is unavoidable in most cases. In our study, we tried to salvage the limb and reconstructive procedure was done to improve the livelihood of the patient having morbidity in daily life because of diabetic foot. For that we had done free flap in patients with defect over weight bearing area or defect with exposed bones and tendons. Free flap was done when the patient had good vascular supply confirmed with lower limb arterial color doppler. Other patients where free flap was not an option, the local flap or skin grafting was done.

In our study, out of 50 cases studied, there was a marked male predominance in occurrence of diabetic foot lesion. 34 (68%) were male patients and 16 (32%) cases female patients with Male: Female ratio of 2.12:1. Jennifer A et al and Mayfield et al studied age wise distribution in diabetic patients which had 32 male (53%) and 29 females (47%). Incidence is more among the male in our study because among males more were doing outdoor work or labor, so there is more chance of trauma and its consequences compared to person doing household work.

In our study, out of 50 cases, most common presentation was ulcer with 27 (54%) cases, followed by 9 (18%) cases with cellulitis. Incidence of gangrene in the present series was comparatively lesser to that of 8 in Bell series (1960).[18] Incidence of ulcer is comparable to the study by Shridharan et al, which had incidence of ulcer in 44% cases of diabetic foot, followed by cellulitis with 20% cases.[19]

Out of 50 cases studied in this series, the most common site of occurrence was on dorsum of foot, which was seen in 24 cases (48%), where as in Apelquist et al, and Reiber et al, study the common site was toes which was 51% and 52% respectively.[20,21] Heel in 10 cases (20%) was the least common site to be involved in the present study. In present study, out of the 50 cases studied, 17 patients (34%) had history of trauma and 33 patients (66%) had history of prior infection, which is comparable to the study by Jannifer A and Mayfield et al where trauma was present in 27 (44%) cases.[17]

In the present study 33 (66%) cases were found to have neuropathy. The, majority of the patient had history of diabetes of more than 5 years. This shows that peripheral neuropathy is common in long standing diabetic patients. Grams et al, noted neuropathy in 84 cases (31.81%) out of 264 total cases, whereas Duncan et al noted neuropathy 125 cases (35.31%) out of 354 total cases. In Pennsylvania (1969) series 28.5 % cases had neuropathy.[22-24] Greater amount of neuropathy incidence could be due to lack of awareness and ignorance to the diabetic foot syndrome in patients with long standing diabetes. In our study, split thickness skin grafting was done in total 29 cases, among which total graft loss was noted in 1 (2%) case, which was managed by redo split thickness skin graft and partial graft loss occurred in 8 (16%) cases, among which 5 cases were managed conservatively and 3 cases were managed by split thickness skin graft. Total 4 cases out of 9 with graft loss was managed by secondary surgery.

In study done by Yeh et al, total 10 cases had non healing, among which 2 cases were managed by secondary skin grafting, 3 cases by stump revision surgery and 5 cases were managed conservatively. In a review series done by Crystal et al, Ramanujam et al, Zgonis et al, 24.5% cases had complications in which most common was wound dehiscence in 66% cases with complication, which is comparable to our study.[25,26]

In our study, average hospital stay is 25 days which is lower in compare to study done by Yeh et al (2010), which had average hospital stay of 53 days. The management of diabetic foot ulcers often requires

reconstructive procedures to promote wound healing and prevent further complications. Several reconstructive modalities, including skin grafts, local flaps, and free flaps, are commonly used in the management of diabetic foot ulcers. Each modality has its own advantages and considerations, and the choice of technique depends on the individual patient's condition and the characteristics of the wound.

Skin grafts are a well-established method for wound closure in diabetic foot ulcers. They involve transferring a thin layer of healthy skin from one area of the body (donor site) to cover the ulcerated area. Skin grafts are useful for larger wounds over dorsum of foot and over non weight bearing area of sole. However, they may have limitations in cases of complex wounds, as they may not adequately address the underlying tissue loss.

Local flaps are another option for diabetic foot ulcer reconstruction. They involve transferring adjacent healthy tissue to cover the wound. Local flaps provide better vascularity and tissue thickness compared to skin grafts, but there is limited tissue availability making them suitable only for small to medium sized wounds. They can also address tissue loss and improve wound healing. However, local flaps may require more surgical expertise and have limitations in cases of inadequate local tissue availability or compromised blood supply.

Free flaps are a more complex reconstructive option that involves transferring healthy tissue from a distant site to cover the diabetic foot ulcer. Free flaps provide a robust blood supply and can effectively address tissue loss and infection. They are particularly useful for large or complicated wounds where other modalities may be insufficient. However, free flaps require microsurgical expertise and longer operative times. They also carry the risk of donor site morbidity and require careful monitoring postoperatively. High failure rate in free flap reconstruction in diabetic foot is noted due to multiple factors, like- infection, old age, atherosclerosis, diabetic arteriopathy, hypercoagulability, etc.

CONCLUSION

The choice of reconstructive modality in the management of diabetic foot ulcers should be based on the specific characteristics of the wound and the patient's overall condition. Skin grafts are suitable for larger wounds over dorsum of foot and wounds over non weight bearing area of sole, while flaps provide stable, supple, durable, and sensate coverage. Local flaps give better tissue match and free flaps offer the most extensive reconstructive capabilities but come with increased surgical complexity. To prevent recurrence, well-padded flap with sensate coverage is needed, but in cases of diabetic foot, it is difficult to achieve sensation as over the period diabetic neuropathy settles in. Foot wear and splintage is helpful in altering pressure over the abnormal pressure points. Frequent check up of foot is necessary for early diagnosis of any developing ulcer. Ultimately, the selection of the appropriate reconstructive modality should be made to ensure the best possible outcome for the patient.

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