Al-Azhar International Medical Journal

Volume 4 | Issue 7 Article 11

7-1-2023

Section: Orthopedics, Plastic surgery

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How to Cite This Article

El-Banoby, Tarek Mahmoud Youssef; Dahshan, Hazem Hussein; and Zidan, Belal Ismail Hassan (2023) "Role of free-tissue transfer in diabetic foot salvage with systematic review," *Al-Azhar International Medical Journal*: Vol. 4: Iss. 7, Article 11.
DOI: https://doi.org/10.58675/2682-339X.1881

ORIGINAL ARTICLE

Role of Free-tissue Transfer in Diabetic Foot Salvage With a Systematic Review

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Abstract

Background: **Lower extremity wounds that do not heal are still a difficult problem for reconstructive surgery. Over 50% of all amputations are caused by diabetes mellitus (DM) foot and peripheral artery illness.**

Aim and objectives: **The goal of this research was to evaluate of the free flap in the diabetic foot as regards eradication of infection, coverage durability, and lower extremity function.**

Patient and methods: **The research was done at the AL-Azhar University Department of Plastic and Reconstructive Surgery. From patients hospitalized at the Department of Cosmetic and reconstructive surgery at AL-Azhar University, 20 diabetes mellitus patients with lower extremities defects had been chosen for a prospective cohort study for follow-up at 6 months after surgery.**

Results: **Patients with failed flaps have statistically significantly higher defect number, higher planter defect, and higher defect size and depth than good outcome flaps. Patients with failed flaps have statistically significant higher infected wound beds, lower granulation tissue, higher lacerated surrounding tissue, higher osteomyelitis, and higher nonfelt pulsation than good outcome flaps. Patients with failed flaps have statistically significant higher bad coverage durability, lower eradication of infection, higher impaired lower extremity function, and higher rate of lost superficial and deep sensation than good outcome flaps. Patients with failed flaps have statistically significant higher blood pressure than good outcome flaps. Patients with failed flaps have statistically significant higher leucocytic count than good outcome flaps.**

Conclusion: **The keystones of treatment are to eradicate infections, cover wounds with well-vascularized tissue, and simultaneously control comorbid conditions.**

Keywords: Diabetic foot salvage, Free-tissue transfer, Plastic and reconstructive surgery

1. Introduction

It is no secret that diabetes mellitus (DM) has a considerable negative impact on patients' morbidity and costs the healthcare system a lot of money.[1]

Lower extremity wounds that do not heal are still a difficult problem for reconstructive operations. Over half of all amputations are caused by DM foot and peripheral artery diseases.[2]

Because they are associated with considerably worse health-related quality-of-life in individuals with skin ulcers impacting the lower leg, major amputations should be avoided if feasible. Additionally, patients and their families are significantly impacted by the social and economic effects of lower limb amputation.[3]

Local random flaps in DM foot showed bad healing, multiple complications, and need for revision surgery.[4]

High rate of failure owing to poor stability at DM patient, split-thickness skin graft (STSG) insertion has seldom been mentioned as a major method of treating wounds, especially those on the DM foot.[5]

In the existence of segmental arterial affection, DM foot restoration utilizing free flaps raises 5-year survival rate due to the addition of vasculature compared with local flap; similarly, well-vascularized

Accepted 24 January 2023.
Available online 20 November 2023

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https://doi.org/10.58675/2682-339X.1881

soft tissue coverage can be an effective method of treating DM leg ulcers, but only in the existence of optimal distal limb vascularity.[6]

Free tissue transfer is still a crucial therapy option for many disorders. In fact, it has been shown that microvascular restoration for DM limb salvage increases the patients' 5-y survival rate.[7]

The goal of this research was to evaluation of free flap in DM foot as regard eradication of infection, coverage durability, and lower extremity function.

2. Patients and methods

The research was done at the AL-Azhar University Department of Plastic and Reconstructive Surgery. From patients hospitalized at the Department of Cosmetic and reconstructive surgery at AL-Azhar University, 20 DM patients with lower extremities defects had been chosen for prospective cohort research for follow-up at 6 months after surgery.

2.1. Inclusion criteria

Age: the age (up to 65 years), sex: both sexes are included, and at least two patent arteries of main lower limb arteries.

2.2. Exclusions criteria

Patient with a single patent artery in the lower limb, a patient unfit for surgery, an uncooperative patient, uncontrolled DM (HbA1c > 7% or Acetone in urine), and a patient resistant to insulin.

2.3. Preoperative

2.3.1. History taking

A sheet was performed for all patients included in this study, including: Personal history: name, age and sex. DM history: type, Duration and medication. Wound history: cause, Duration and respond to treatment. Past history: including: History of previous therapy, history of previous operations, and history of diabetes mellitus or hypertension. Family history: history of similar conditions.

2.3.2. Examination

General examination: Evaluation of vital signs (Pulse, Bl.p, RR, Temperature), measurement weight, height (BMI), Lower limb edema and over view on the body systems. Local examination: Defect analysis as regard number, site, size, depth, wound bed, granulation tissue and surrounding, vascular assessment, assessment of superficial sensation and deep sensation, assessment of osteomyelitis and assessment of ulcer.

Investigations: LAB: Complete blood count (CBC)/ INR/S.Creatinine/liver function test/HbA1C/insulin resistance tests (oral glucose tolerance test, fasting glucose test).

Radiology: Radiography to exclude osteomyelitis, biopsy, conventional angiography, computed tomography (CT) angiography and duplex for donor site artery assessment.

Biopsy: Bone biopsy to exclude osteomyelitis and swab culture from the ulcer

Written Consent: After patient consultation with oral and written form include hazard of surgery, Donor site morbidity, and flap failure.

Procedure: All patients had their vascular health checked before the surgery. Conventional angiography is superior to preoperative CT angiography because it provides more precise information about the recipient artery and the perforator of the vascular fellow of the foot.

2.4. Surgery steps

2.4.1. Type of anesthesia

The Type of anesthesia is deep controversies according to general anesthesia or regional anesthesia (spinal or epidural) as regard anesthesia is preferred over regional anesthesia to avoid hypotension of peripheral vessels occurring after regional anesthesia, especially in epidural which lead to un pulsating recipient Vessels, cannot be accumulated for anastomosis.

2.4.2. Recipient vessels

To guarantee success as shown by Doppler, pay special attention to the recipient's arterial input and venous outflow.

2.4.3. Position

The patient should be placed in the supine position, which permits flap harvest and normally needs no position modifications (Fig. 1a).

2.5. The anterolateral thigh (ALT) flap harvest

2.5.1. Marking

Identify and mark the vastus lateralis-rectus femoris septum, (Fig. 1b).

2.5.2. Team work

The team responsible for the debridement and exploration of recipient's vessels while the other team elevation and harvested the flap.

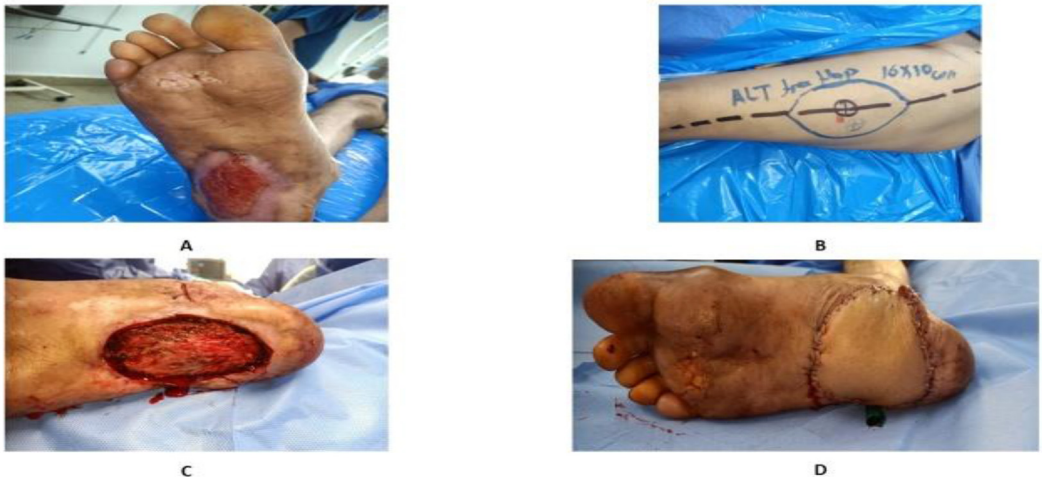

Fig. 1. (A) Preoperative photo 46 years old man with diabetic ulcer at the soul of right foot, (B) Marking of doner (anterolateral thigh) flap by Doppler, (C) Debridement of the ulcer, (D) Immediate post operative.

2.5.3. Surgical procedures for ALT flap harvest

Cuts in the skin It is preferable to make the incision above the fascia from the beginning in the superficial plane to create a coutanous flap rather than down through the rectus femoris fascia and raise the lateral flap in the subfascial region until the muscular septum between the rectus femoris and the vastus lateralis muscle is described.

Mobilization of the pedicle, with digital dissection, the rectus femoralis may be readily detached, medially retracted, and the pedicle revealed above the vastus intermediate muscle. The lateral circumflex femoral artery (LCFA) bifurcation marks the point at which the pedicle is mobilized.

Skeletonization of perforators, Retrograde motion skeletonizes the perforators that stretch from the fascia lata to the pedicle. The vastus lateralis must typically be dissected in order to identify the musculocutaneous perforators, but they may be going via the septum (septocutaneous).

Flap mobilization, the flap may be mobilized after the lateral incision is made above or below the fascia lata. The pedicle is transected when the recipient site is prepared.

Closure A first wound closure is carried out and a drain is implanted.

2.5.4. Debridement

Planning for both reconstruction and debridement requires an understanding of the foot angiosome's vascular distribution. When creating a local flap that might result in flap breakdown in patients with inadequate vascular perfusion, one should avoid entering the angiosome's region. The marginal vascularization from the healthy surrounding angiosome territory that happens when debridement is done according to the angiosome territory will increase flap survival. Additionally, any nonviable and contaminated soft tissue and bone should be removed during debridement (Fig. 1c).

Prior to severing the flap pedicle, double-check the recipient vessel.

2.5.5. Postoperative

If the distal pulses were not discernible by clinical examination, a hand-held Doppler was employed. Clinical assessments included monitoring flap refilling, color, temperature, and Doppler assessment every hour in the first 48 h, every 4 h in the first week, daily for two weeks, and monthly assessments for 6 months. Patients were also kept in bed for the first two days following surgery to aid in healing. He can get out of bed and sit in a chair with the leg lifted after two days. For the first three weeks, it's crucial to keep the leg up as much as you can, and the patient should wear a half-shoe to relieve pressure on the foot.

2.6. Evaluation

2.6.1. Subjective

Photography: (Preoperative, IntraOperative, and postoperative monthly for 6 month), Gait assessment: (PreOperative and postoperative monthly for 6 month) and Questionnaire: (psychological impact, assess flap sensation, aesthetic appearance, return to normal physical activity).

2.6.2. Objective

Color duplex at 1, 3 and 6 months and video gait assessment

2.6.3. Ethical considerations

The plastic surgery department's ethical committee at AL Azhar University's faculty of medicine had submitted the study protocol for approval. Each person who participated in the research has given informed verbal and written permission after being informed of its goals and methods. At every stage of the research, confidentiality and personal privacy have been protected.

3. Results

Table 1.

Patient with failed flaps have statistically significant higher age, higher smoking and higher rate of associated comorbidity than good outcome flaps (Figs. 2 and 3, Table 2).

Patient with failed flaps have statistically significant higher defect number, higher planter defect and higher defect size and depth than good outcome flaps (Table 3).

Patient with failed flaps have statistically significant higher infected wound bed, lower granulation tissue, higher lacerated surrounding tissue, higher osteomyelitis and higher nonfelt pulsation than good outcome flaps (Fig. 4).

Patient with failed flaps have statistically significant higher infected wound bed, lower granulation tissue, higher lacerated surrounding tissue, higher osteomyelitis and higher nonfelt pulsation than good outcome flaps (Table 4).

Table 1. Comparison of age and sex of good and failed outcome flap.

	Good outcome $N = 15$		Failed $N = 5$		Independent student t-test	
	Mean	SD	Mean	SD	t	P-value
Age (years)	44.67	8.35	54.00	3.81	−3.398	0.004
BMI	31.13	3.25	33.80	2.77	−1.780	0.113
	Good outcome		**Failed**		**Chi square test**	
	N (%)		N (%)		χ^2	P-value
Sex						
Males	11 (73.30%)		3 (60.00%)		0.317	0.573
Females	4 (26.70%)		2 (40.00%)			
Smoking						
No	10 (66.7%)		0		6.667	0.010
Yes	5 (33.3%)		5 (100.0%)			
Comorbidities						
No	10 (66.7%)		0		12.444	0.014
CAD	1 (6.7%)		2 (40.0%)			
HTN	1 (6.7%)		3 (60.0%)			
COPD	2 (13.3%)		0			
CKD	1 (6.7%)		0			

There is no statistically significant different between patients with failed flaps and good outcome flaps (Table 5).

Patient with failed flaps have statistically significant higher bad coverage durability, lower eradication of infection, higher rate of toe amputation, more impaired flap sensation, greater impaired lower extremity function, higher rate of lost superficial and deep sensation in the lower limb than good outcome flaps (Fig. 5).

Patient with failed flaps have statistically significant higher bad coverage durability, lower eradication of infection, higher impaired lower extremity function, higher rate of lost superficial and deep sensation than good outcome flaps (Table 6).

Patient with failed flaps have statistically significant higher psychological impact, loss aesthetic appearance, impaired physical activity, worse gait than good outcome flaps (Fig. 6).

Patient with failed flaps have statistically significant higher impaired flap refilling, altered color, higher cold temperature, higher psychological impact, impaired flap sensation, loss aesthetic appearance, impaired physical activity, worse gait than good outcome flaps.

4. Discussion

There are already 55 million individuals living with DM in Europe, according to estimates. Up to 15% of them will eventually have a foot ulcer. DM patients with foot ulcers have a higher death rate compared with those with healthy feet (15% poorer survival at 3 years), a worse quality of life, and are more likely to need an amputation Standl and colleagues.[8]

The study's objective was to assess free flap in DM foot as regard eradication of infection, coverage durability, lower extremity function.

20 patients with lower extremity defects who have been hospitalized to the department of plastic and reconstructive surgery at AL-Azhar University will be chosen as part of a prospective cohort research for follow-up at six months after surgery.

The current study included 20 DM patients; 14 were males and 6 were females. Their age ranging between 35 and 65 years with median value of 47.000 ± 8.460 years. The mean BMI was 31.800 ± 3.280. 50% were smokers. Regarding associated comorbidities, 20% have hypertension, 15% have coronary artery disease, 10% have COPD and 5% have chronic kidney disease.

Thai and colleagues,[9] sought to identify the variables influencing the success of free flap repair in the management of osteomyelitis. Microvascular free flaps were used to treat 65 individuals with

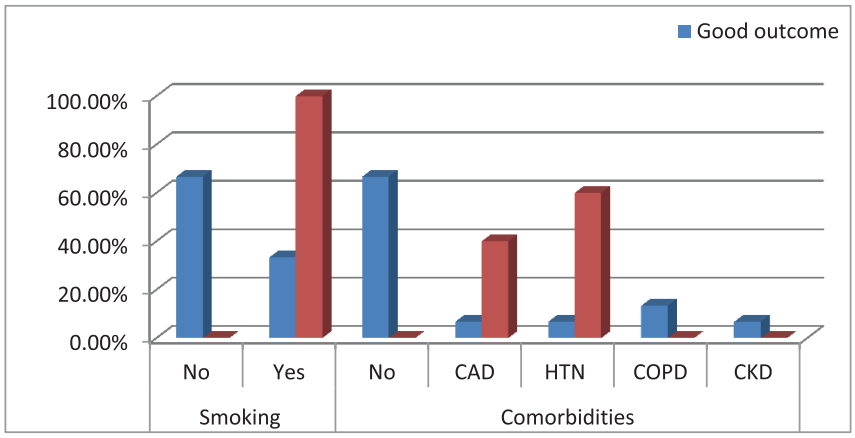

Fig. 2. Smoking and comorbidity in failed and good outcome flaps.

lower leg osteomyelitis. There were 49 male patients and 16 female patients; the mean age was 51.2 ± 15.8 (interquartile range, 18–82 years). 24 of the patients smoked regularly. Thirty-one patients had DM, 21 required angioplasty due to significant lower extremities artery occlusion, and five had ESRD.

O'Connor and colleagues,[10] showed that All studies that were included in the systematic review documented the debridement of diseased bone and devitalized soft tissue prior to free tissue transplantation. However, only two research discussed simultaneous debridement and transfer of free tissue. Thirteen studies particularly discussed osteomyelitis. Prior to debridement and free tissue transfer, 55% of operated patients developed osteomyelitis, according to descriptions.

Breidung and colleagues,[11] showed that they may have room for 25 patients in their research. 20 (80%) of these patients were males, while 5 (20%) were women. The patient group's average age was 40.3 ± 19.1 years. DM was the most prevalent comorbidity, affecting seven patients (28% of the total), followed by peripheral arterial diseases ($n = 5/20\%$), hypertension ($n = 3/12\%$), drug misuse ($n = 2/8\%$), and smoking ($n = 2/8\%$).

Lee and colleagues,[7] showed that the median follow-up was 12.0 19.4 mo among the 33 patients that were found in their database and subjected to the study. The majority of the patients were men, and the median patient age was 54 years old. Preoperative comorbidities included smoking in five (15.1%) patients, CAD and ESRD in four (12.1%) patients, and CAD and ESRD in three (9.1%) patients who presented with both conditions.

Chang and colleagues[12] showed that all of the patients had concomitant conditions. The following

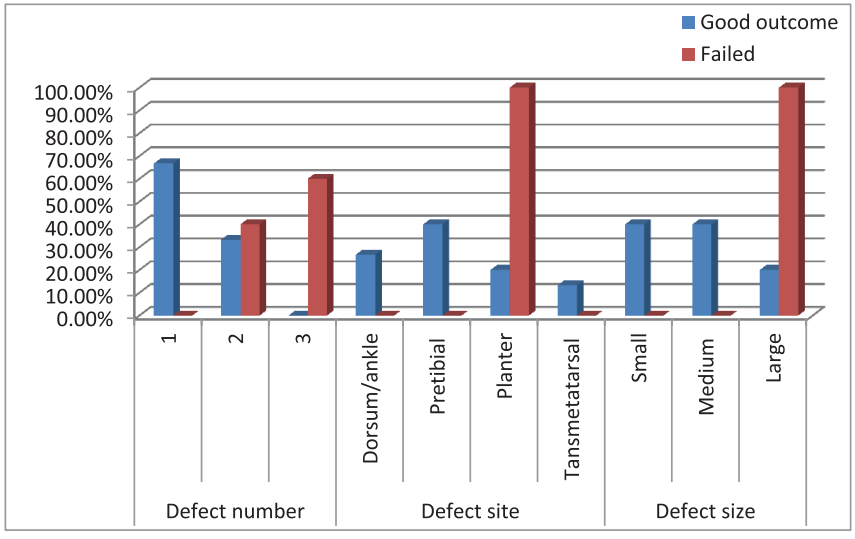

Fig. 3. Tissue defect characteristics of good and failed flap.

Table 2. Comparison of tissue defect characteristics of good and failed flap Patient with failed flaps have statistically significant higher defect number, higher planter defect and higher defect size and depth than good outcome flaps.

	Good outcome $N = 15$ N (%)	Failed $N = 5$ N (%)	Chi square/ independent t-test	
			χ^{22}	P-value
Defect Etiology				
Trauma	9 (60.0%)	1 (20.0%)	2.756	0.252
Infection	4 (26.7%)	2 (40.0%)		
Vasculopathy	2 (13.3%)	2 (40.0%)		
Defect type				
Exposed tendon	7 (46.7%)	0	3.590	0.083
Exposed bone	8 (53.3%)	5 (100.0%)		
Defect number				
1	10 (66.7%)	0	12.381	0.002
2	5 (33.3%)	2 (40.0%)		
3	0	3 (60.0%)		
Defect site				
Dorsum/ankle	4 (26.7%)	0	10.000	0.019
Pretibial	6 (40.0%)	0		
Planter	3 (20.0%)	5 (100.0%)		
Transmetatarsal	2 (13.3%)	0		
Defect size				
Small (<100 mm)	6 (40.0%)	0	10.000	0.007
Medium (100–200 mm)	6 (40.0%)	0		
Large (>200 mm)	3 (20.0%)	5 (100.0%)		
Wound depth (mm)				
Mean ± SD	0.580 ± 0.142	0.800 ± 0.100	−3.800	0.004

were the most typical: 39 (48%) had hypertension, 21 (45%) had renal failure, 16 (27%) had CAD, and 10 (17%) had a stroke.

The defect etiology was traumatic in 50%, infection in 30% and vasculopathy in 20% of cases. wound defect expose tendon in 35% and expose bone in 65%, defect number was 1 in 50%, 2 in 35% and 3 in 15% of cases. Most of cases 40% have planter defect followed by 30% have pretibial defect. Defect size was small in 30%, medium in 30% and large in 40%. The wound depth ranged between 0.4 and 0.9 mm. Surrounding tissues was lacerated in 35% of cases. 15% have infected wound bed. 70% have granulation tissue. 35% develop osteomyelitis. Pulsation was not felt in 35% of cases.

Table 3. Comparison of tissue wound examination of good and failed outcome flap.

	Good outcome $N = 15$ N (%)	Failed $N = 5$ N (%)	Chi square	
			χ^2	P-value
Wound bed				
Normal	15 (100.0%)	2 (40.0%)	10.588	0.009
Infected	0	3 (60.0%)		
Granulation tissue				
NO	1 (6.7%)	5 (100.0%)	15.556	<0.0001
Yes	14 (93.3%)	0		
Surrounding tissue				
Healthy	13 (86.7%)	0	12.381	<0.0001
Lacerated	2 (13.3%)	5 (100.0%)		
Osteomyelitis				
No	13 (86.7%)	0	12.381	<0.0001
Yes	2 (13.3%)	5 (100.0%)		
Pulse assessment (dorsalis pediS artery)				
Intact	**13 (86.7%)**	**0 (0.0%)**	**12.381**	**<0.0001**
Not felt	**2 (13.3%)**	**5 (100.0%)**		

Thai and colleagues,[9] showed that the foot (43.1%) was the area with the highest abnormalities, followed by the tibia, heel, and ankle (14 patients, 13 patients, and 6 patients, respectively). 29 individuals had osteomyelitis related to DM foot ulcers, and 29 patients had osteomyelitis after trauma. The other factors were skin infections, burns, and pressure sores.

Breidung and colleagues,[11] showed that the typical flaw measured 127 cm^2 (range: 20 cm^2–400 cm^2). An average of 32.8–43.6 days passed on average for those with trauma as the etiology before receiving surgical therapy. In 12 (48%) instances, the heel was the defect location. In one (4%) case, the plantar midfoot was, and in two (8%) cases, the plantar forefoot was. Nine (36%) problem cases included the dorsum of the foot, whereas eight (32%) involved the ankle. Since several defect scenarios comprised numerous foot regions, the total number of defect sites outweighed the total number of microsurgical operations.

Regarding the flap type 45% were anterolateral thigh, 20% were latissimus dorsi, 15% were vastus lateralis followed by SCIP free flap and M. gracilis in 10% for each. Anterior tibial artery, posterior tibial artery, and dorsalis pedis artery were the recipient arteries in 30%, 55%, and 15%, respectively.

Thai and colleagues,[9] showed that The ALT flap (92.3%), three medial sural artery perforator flaps, one superficial circumflex iliac perforator flap, and one thoracodorsal artery perforator flap were the most frequently utilized procedures. Out of 65 instances, six (9.23%) patients had entire flap loss. Three of the six unsuccessful flap replacement attempts with fresh fasciocutaneous free flaps were successful. The remaining three patients received secondary healing and further debridement using split-thickness skin grafts or NPWT.

Lee and colleagues,[7] showed that The ALT flap (92.3%), three medial sural artery perforator flaps, one superficial circumflex iliac perforator flap, and one thoracodorsal artery perforator flap were the most frequently utilized procedures. Out of 65 instances, six patients (9.23%) had entire flap loss. Three of the six unsuccessful flap replacement attempts with fresh fasciocutaneous free flaps were successful. The remaining three patients received

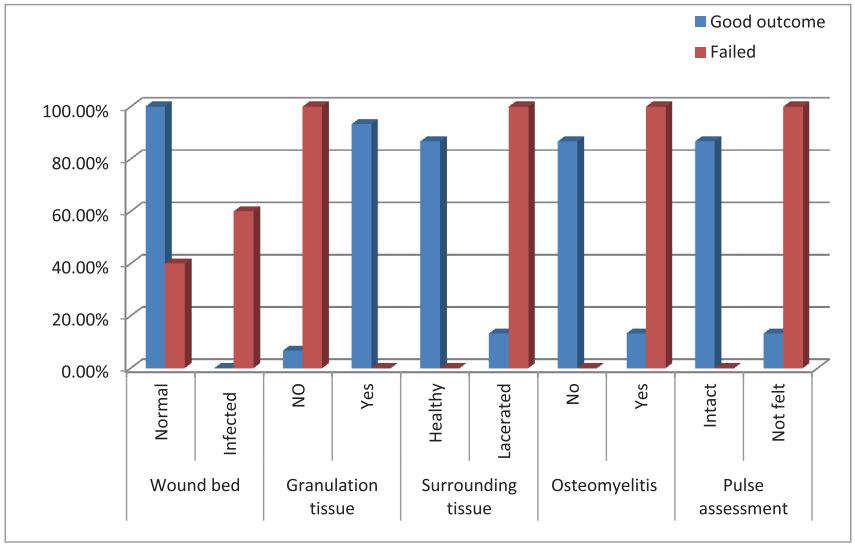

Fig. 4. Wound management in good and failed flap.

secondary healing and further debridement using split-thickness skin grafts or NPWT.

This is in conflict with O'Connor and colleagues[10] who demonstrated that four studies employed a single flap type on all of their patients in their systematic review. The specifics of which flap was employed for each kind of defect discovered were provided by five investigations. 63% of the flaps employed were muscle flaps, 35% were fasciocutaneous flaps, and nine omental flaps from three investigations were also included. Muscle-only flaps with split skin graft coverings were employed. The usage of a myocutaneous flap has not been formally studied. 12 studies employed the rectus muscle flap the most often, accounting for 29% ($n = 161$) of all flaps, while Hong's series of 71 patients represented the bulk of anterolateral thigh flaps. Six of the 18 investigations used flap anastomosis only into native foot arteries. Interposition vein grafts were used in five investigations to lengthen the pedicles for flap anastomosis.

Flap refilling was impaired, color was altered, and temperature was cold in 25% of cases. Flap was failed in 25% of cases. 60% of cases have psychological impact, 40% have impaired flap sensation and 55% loss their aesthetic appearance. 75% return to normal physical activity and gait assessment at follow up was improved in 60%, not improved in 25% and worse in 15%.

Table 4. Comparison of clinical characteristics of the used flap between good and failed outcome flap.

	Good outcome $N = 15$ N (%)	Failed $N = 5$ N (%)	Chi square test	
			χ^2	P-value
Flap type				
Latissimus Dorsi	3 (20%)	1 (20.0%)	1.481	0.830
Anterolateral Thigh	7 (46.7%)	2 (40.0%)		
Vastus Lateralis	2 (13.3%)	1 (20.0%)		
SCIP free flap	2 (13.3%)	0		
M. Gracilis	1 (6.7%)	1 (20.0%)		
Recipient artery				
Anterior tibial artery	4 (26.7%)	2 (40.0%)	0.606	0.739
Posterior tibial artery	9 (60.0%)	2 (40.0%)		
Dorsalis pedis artery	2 (13.3%)	1 (20.0%)		

Table 5. Comparison of wound management between good and failed flap.

	Good outcome $N = 15$ N (%)	Failed $N = 5$ N (%)	Chi square test	
			X2	P-value
Toes				
Not amputated	10 (66.7%)	0	6.667	0.010
Amputated	5 (33.3%)	5 (100.0%)		
Eradication of infection				
Yes	15 (100.0%)	2 (40.0%)	10.588	0.001
No	0	3 (60.0%)		
Coverage durability				
Good	15 (100.0%)	0	20.000	<0.0001
Bad	0	5 (100.0%)		
Lower extremity function				
Preserved	12 (80.0%)	0	10.000	0.002
Impaired	3 (20.0%)	5 (100.0%)		
Lower extremity Superficial sensation				
Intact	15 (100.0%)	0	20.000	<0.0001
Lost	0	5 (100.0%)		
Lower extremity Deep sensation				
Intact	15 (100.0%)	2 (40.0%)	10.588	0.009
Lost	0	3 (60.0%)		
Flap sensation				
Intact	12 (80.0%)	0	10.000	0.002
Impaired	3 (20.0%)	5 (100.0%)		

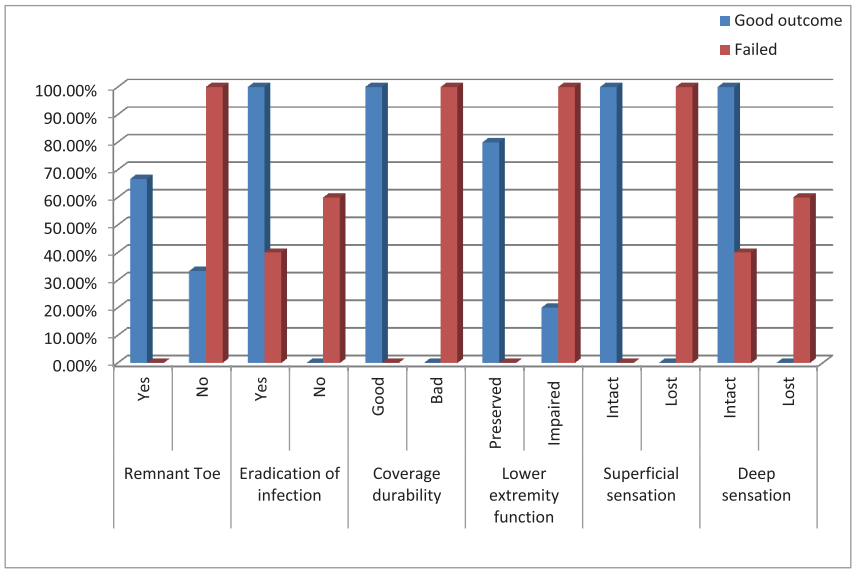

Fig. 5. Wound management in good and failed flap.

Chang and colleagues,[12] showed that the overall flap rate of success was 95%. Also, Lu and colleagues[13] showed that in this series, the total flap success rate was 93%. Four (14%) patients, out of the 29 free flaps used for DM foot reconstruction, had to be returned to the operating room due to microvascular impairment and bleeding. In two of these takebacks, the flap was salvaged. On postoperative day 8, delayed venous thrombosis led to the first flap demise that the operating room determined was unsalvageable. The patient was given conservative care until a skin transplant could be properly implanted, including negative pressure wound treatment and a dermal replacement. In the second instance of flap loss, a patient with severe PVD and a prior ankle arthrodesis had single-vessel flow to the lower extremities. For occupational reasons, the patient wanted aggressive limb salvage measures, therefore FTT transfer was tried. The artery and a single deep vena comitantes were anastomosed end to side (no other veins, deep or superficial, were suitable). The flap's intraoperative flow was found to be a little slow, but there was no immediate indication that the flap might fail.

Table 6. Comparison of flap outcome in good and failed flap.

	Good outcome $N = 15$ N (%)	Failed $N = 5$ N (%)	Chi square test	
			χ^2	P-value
Psychological impact				
Yes	12 (80.0%)	0	10.000	0.002
No	3 (20.0%)	5 (100.0%)		
Aesthetic appearance				
Yes	9 (60.0%)	0	5.455	0.020
No	6 (40.0%)	5 (100.0%)		
Return to normal physical activity				
Yes	15 (100.0%)	0	20.000	<0.0001
No	0	5 (100.0%)		
Gait assessment at follow up				
Improved	12 (80%)	0	13.600	0.001
Not improved	3 (20%)	2 (40%)		
Worse	0	3 (60%)		

The mean heart rate of the studied population was 79.8 ± 5.01 beat/min, the mean respiratory rate was 17.85 ± 1.18 cycle/min. the mean temperature was 37.10 ± 0.31 and the mean SBP was 123.00 ± 24.46 mmHg and the mean DBP was 79.25 ± 13.98 mmHg.

Aziz et al.,[14] showed that Systolic BP (mmHg) was 129 ± 15.8, Diastolic BP (mmHg) was 79.6 ± 9.3.

Lu and colleagues,[13] showed that the median glycated hemoglobin (HbA1c) was 7.5% (r, 5–11%), and the median body mass index (BMI) was 31 kg/m^2 (r, 23–45 kg/m^2).

Yun and colleagues,[15] showed that the median HbA1c level was greater in the group with DFUs (9.2 1.3% [77.2 ± 14.2 mmol/mol] vs. 8.1 1.3% [65.3 ± 13.4 mmol/mol]; $P < 0.001$).

Aziz and colleagues,[14] showed that HbA1c % (g/dl) was 7.8 ± 1.5.

Assi and colleagues,[16] showed that with a median HbA1c (glycated hemoglobin) of 7.7% and a median glucose level of 168 mg/dL, all patients in the DM group had type 2 DM. Road accidents were the only source of soft tissue abnormalities in all trauma cases.

Patients with failed flaps has statistically significant higher age, higher smoking, and a higher rate of associated comorbidity than good outcome flaps.

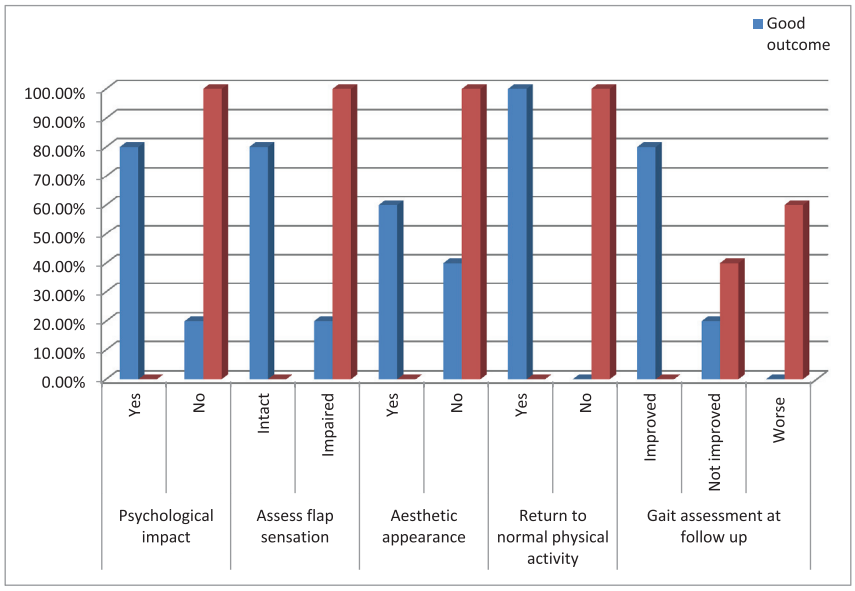

Fig. 6. Outcome in good and failed flap.

Lee and colleagues,[7] showed that in comparison to women, males were shown to have a considerably lower percentage of complete flap failures (0% vs 27.3%, P¼ 0.012). In addition to the choice of flap and recipient arteries employed, it was discovered that the existence of medical comorbidities such as CAD, peripheral vascular disease (PVD), ESRD, and cigarette use was not substantially linked with results.

Similar to our results, O'Connor and colleagues[10] showed that within the group under consideration, obviously substantial PVD is quite frequent, with 66% of patients requiring some kind of bypass surgery before free tissue transfer. Unfortunately, the precise results of DM and non-DM neuroischaemic ulcers were not discussed in great detail. When compared with isolated neuropathic ulcers, neuroischaemic ulcers are often linked to worse outcomes in ulcer care.

This is not concordant with Chang and colleagues[12] who showed that Gender, age, the Wagnere-Meggit classification, the location of the lesion, and end-stage renal illness had no statistically substantial effects on the success of limb salvage. Major limb amputation risk was increased by both TASC D vascular lesions and the length of time between endovascular revascularization and free tissue rebuilding ($P = 0.043$ and 0.036, respectively).

Patient with failed flaps have statistically significant higher infected wound bed, lower granulation tissue, higher lacerated surrounding tissue, higher osteomyelitis and higher non-felt pulsation than good outcome flaps.

O'Connor and colleagues,[10] showed that for 399 patients, a description of the wound's location was provided: The dorsum of the foot accounted for 12% of the cured wounds, the forefoot or lateral side for 30%, the plantar aspect for 10%, the heel for 24%, and the lower leg or ankle for 24%. According to one research, there were a certain number of patients who couldn't be saved after an examination.

There is no statistically significant different between patients with failed flaps and good outcome flaps.

In large cohort studies by Apleqvist and Lepantalo,[17] and Söderström and colleagues,[18] Patients' success has often been gauged by their ability to prevent major amputations at or above the ankle in cases of DM and foot ulcers. Information on the likelihood of full wound healing after surgical operations in DM individuals is scarce.

Patient with failed flaps have statistically significant higher bad coverage durability, lower eradication of infection, higher impaired lower extremity function, and higher rate of lost superficial and deep sensation than good outcome flaps.

Eskelinen and colleagues[19] showed that Minor issues affected three patients: partial flap necrosis in one flap and wound hematoma in two flaps, all of which improved after revision. Major problems occurred in three additional patients. One patient had arterial thrombosis, which was effectively treated, and the flap recovered totally. Another patient suffered a significant amputation. The bacterial cultures revealed that he had a heel ulcer, osteomyelitis, and a persistent infection with MRSA (type FIN-16 (125: IA)). Despite a successful free flap transfer, the limb had to be amputated due to

osteomyelitis and an infection that would not go away. The third patient had a multiorgan failure, entire flap loss, and sepsis, which resulted in death 26 days after surgery. This patient had pancreatic cancer as a preexisting illness, which had metastatic spread. Therefore, 9% of patients died within 30 days after entering the hospital.

4.1. Limitations

Therefore, further research should be done on these patients. Despite these drawbacks, we think that our research demonstrated the effectiveness of free flaps in the management of osteomyelitis and limb preservation even in patients with co-morbidities.

4.2. Conclusion

Free flap is considered a very important issue in DM foot as it increases survival rate of foot by eradication of infection and coverage of the ulcer with well vascularized tissue, and also it avoids immediate amputation due to osteomyelitis and infection but can not be avoid future amputation due to vasculopathy and neuropathy.

Authorship

All authors have a substantial contribution to the article.

Consent for publication

I confirm that every author has consented to submit the work.

Availability of data and material

Available.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Sources of funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of interest

No conflicts of interest.

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