

The 'V' Advancement Flap Sans 'Y' Closure in Treatment of Volar Foot Ulcers

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ABSTRACT

Background: Management of foot ulcer is challenging for plastic surgeons owing to inherent sturdiness of the volar skin and also the necessity to give a robust cover to ensure functionality including weight bearing. This study was conducted to examine the results of our technique of single or double 'V' advancement flap sans the 'Y' closure of the classical 'VY' flap, which was found to be technically simple for the management of plantar ulcers in our foot ulcer patients. **Methods and Material:** 37 patients hospitalized for the management of foot plantar ulcer, who underwent repair with our modified 'V' flap advancement without 'Y' closure technique, at our institution were included in the study. Demographic data, disease-related parameters, technique related complications data were recorded and analysed. Technique complications or sequelae, if any, were accounted. Descriptive statistics was used to summarize the findings. **Results:** In our study, 23 men and 14 women were there with their ages ranging from 15 to 87 years (mean = 54.1 years). The diameter of the ulcers ranged from 14 to 26 mm with mean of 19.3 mm. Unilateral V (-Y) advancement flap was used in 26 cases and in 11 cases bilateral V (-Y) advancement flap was used. Complications included wound dehiscence (3) and partial flap loss (1) of which 3 required redo surgeries while one healed with secondary intention. **Conclusions:** Though a relatively small study group our technique well suited the needs for plantar ulcer wound closure with acceptable complication rate.

Key Messages: Foot ulcer management is a therapeutic challenge which, if managed efficiently reduces encumbrance. Our technique represents a useful and reliable technique with advantages of excellent colour and texture matching and primary donor site closure.

KEY WORDS: VY advancement flap, Plantar foot ulcer, Diabetic ulcer, Malignant foot ulcer, Trophic ulcer, Traumatic ulcer.

Introduction

A volar foot ulcer is described as a full-thickness skin lesion on the plantar side of foot, without mention to time current. Cause for the foot ulcer maybe ischemic, neuropathic, cancer, traumatic, infective or a combination of these.^[1]

The most common causes of chronic foot ulcers are peripheral arterial disease, chronic venous insufficiency, and ulcers due to neuropathy especially in diabetics. Foot ulcers pose a serious risk for infection and amputation, in diabetic patients.^[2] Prevalence of foot ulceration in diabetics is 4–10%.^[3,4]

In chronic wounds, wound healing is disturbed due to disproportionate regeneration and degeneration of extracellular matrix. The basis of abnormal cell proliferation lies in this bioenvironment of chronic inflammation, stimulated mitosis, constant degradation and regeneration. In this structure, potential direct mutagenic effects of toxins released by necrotic tissue are the culprits.^[5] An imbalance of due an abundance of cytokines occurs, which enables cell proliferation and migration and also maintains

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degeneration of extracellular matrix by an increase of matrix metalloproteinases. Also there is loss of immunologically active cells in chronic scar tissue. This is the reason for evasion of malignant cells from immunological detection and subsequent progression locally and thereafter metastases.^[6]

Common cancers of the foot include squamous cell carcinoma (Marjolin's ulcer in chronic wounds), malignant melanoma and basal cell carcinoma.

Squamous cell carcinoma (71%) is most frequently encountered tumour most commonly in burn scars and chronic wounds. Koval-Vern et al found it in 71% of 412 cases of skin burn neoplasms in his review of the literature.^[7] Basal cell carcinoma (12%), melanoma (6%), sarcoma (5%) and other neoplasms (4%) have also been described.^[7] Squamous type accounts for an incidence of 1.5%-2.0% in the lower extremities.^[2,8]

Magnetic resonance imaging is considered as the best method to assess the level and extent of cancer as well as inflammation of soft tissue in these cases.^[7]

Though many methods have been described for closure of the defects due to ulcer on the plantar side of the foot, none is 'fit for all'. Hence type of cover should be tailored for individual patients appropriately taking into account patient and ulcer factors. Sometimes the surgeon has to jump the rungs of the reconstructive ladder to achieve this. Local flaps are best in treatment of plantar ulcers as 'like is replaced with like', faster healing time, relatively less chance of cover failure and complications. However the rigidity and sturdiness of the less mobile plantar skin restricts the use of these local flaps to cover small and medium defects only. One such local flap is the 'VY' advancement flap which has withstood the test of time.

The V-Y advancement flap was originally illustrated by Tranquilli-Leali in 1935,^[9] but was first stated by Atasoy et al,^[10] which he used in treatment of fingertip defects, in 1970.

A VY flap is a "V" shaped flap that, when advanced, is closed in the form of a 'Y' and is a modified advancement flap. Our technique of modification of this VY advancement flap in treatment of plantar ulcers which doesn't require the closure in a 'Y' pattern is based on the above facts. The creation of an islanded "v" shaped tissue deriving its blood supply

from underneath, relative mobility of the plantar skin due to septae attachment to underlying structures and undermining of the surrounding tissue around the islanded flap especially at the opposing bank of the 'V' tip doesn't necessitate to be closed in a 'Y' fashion in treatment of small and medium volar ulcers employing single flap alone or double opposing flaps. Hence this study pertaining to our technique was done to analyse its efficacy.

Methods

Our prospective study constituted of 37 patients, who underwent reconstruction with our modified 'V' flap advancement without 'Y' closure technique. The study was conducted at our institution between January of 2016 and December of 2020. These foot ulcer cases were not amenable to medical line of treatment.

Cases requiring foot / limb amputation, lymph node dissection in cancer, those with inability to walk in the imminent future, those patients unwilling to participate in the study were excluded from the study. In tumour cases, only T₁ / T₂ tumors were selected with no nodal (N₀) or distal metastases (M₀).

Ethical Clearance

Written informed consent was obtained from each patient prior to inclusion in the study and the same was approved by the institutional ethics committee

Sample Size

Sample size for frequency in a population was calculated as such,

Population size [for finite population correction factor (FPC)] (N): 100

Hypothesized % frequency of outcome factor in the population (p): 4% +/-5

Confidence limits as % of 100 (absolute +/- %) (d): 5%

Design effect (for cluster surveys - DEFF): 1

Sample Size (n) for Various Confidence Levels

Equation

Sample size $n = [DEFF * Np(1-p)] / [(d/2)^2 / (Z_{1-\alpha/2}^2 * (N-1) + p(1-p))]$

Confidence	Level (%)	Sample Size
95%	38	
80%	21	
90%	30	
97%	43	
99%	51	
99.9%	63	
99.99%	71	

Results from OpenEpi, Version 3, open source calculator - SSPropor

The basis for calculating sample size is that that V technique is better than Y technique. To say v technique is better, we consider the post-operative complications to be lower. Hence assuming post-operative complication of 4% at 95% confidence level, the estimated sample size is 38.

Preparation for surgery

Investigations were done as per aetiology requirement and as basic requisites for surgery which included radio imaging studies. Biopsy was sent for pathological examination, if needed. MRI was done in all tumour cases before definitive surgery and also other imaging studies were done to exclude nodal / distal metastases.

All cases for the proposed surgery were considered after infection control and prior debridement, if required. Antibiotic coverage was as per hospital antibiotic protocol or based on culture sensitivity report.

Anaesthesia

Cases were operated under local / ankle block / spinal or general anaesthesia as per the case indication and comfort of operating team. Local anaesthesia was generally preferred but other forms were implemented in case of large ulcer ensuing after excision / debridement or when local conditions such as oedema indicated otherwise. General anaesthesia was used when spinal failed.

Surgical Technique

All cases were operated under loupe magnification. Patient position was dependant on the site of the ulcer in volar foot region. In cases of malignancy (confirmed / suspected) excision of the lesion with adequate margin was done. In ulcers with non-cancerous aetiology thorough debridement was done.

To upsurge flap survival, adrenaline was not injected to aid bloodless field. Osteotomy of the underlying bone was done if necessitated.

Planning for unilateral / bilateral advancement using a ‘V’ was done depending on the ulcer size and also local conditions. Oedema, chronicity of the wound leading to toughening and fibrous nature of the surrounding skin demanded employment of dual flaps.

The width of the ulcer dictated the base of ‘V’. It was slightly larger on either sides of the ulcer. Depending on the base, other two sides of the isosceles were drawn so that from the base (leading edge) to the tip it was at least double the base length, however was usually considerably longer. The flap was designed as large as possible to ensure the inclusion of as many perforators as possible. The direction or orientation of the distal point was selected based on adjacent skin laxity and mobility as well as the location of natural or evolving skin creases so that as much as possible the adjacent volar skin could be recruited into the ulcer.

The incisions were carried through the plantar fascia to allow for maximum mobility and viability of the flap. An opposite flap (bilateral) was used to cover a larger defect, with two triangular flaps pointing in reverse direction and the two flaps were brought together and to be sutured together to fill the defect, there as to decrease tension effectively.

Undermining was carried out laterally away from the flap with maximum undermining done on the opposite bank of the flap tip. If necessity arises, certain undermining (minimal) of the tail end of the flap and the leading edge of the flap was done to augment mobility and to dodge tethering of the base of the flap or significant wound tension. The ulcer defect should usually be deepened by removing additional subcutaneous tissue to accommodate the thickness of the incoming pedicle to avoid pin-cushioning of the flap. Flap/s was advanced in a straight line into the defect. After attaining haemostasis, quintessential suture was placed in the middle of the leading edge of the advancing triangular flap/s with vicryl. Additional dissolvable sutures at the corners of the leading edge were applied following. Non Absorbable sutures for the skin completed the wound closure. Important point in this was to advance the flap with adequate mobilization so that it sits comfortably without much

tension in the defect after suturing.

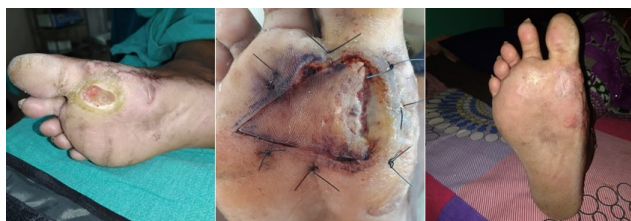


Figure 1: Trophic ulcer in a diabetic patient (left); Unilateral 'V' advancement flap with partial flap necrosis (middle); 2 months after surgery (right)



Figure 2: Malignant melanoma (left); Bilateral 'V' advancement flaps (middle); 2 months after surgery (right)

Cases with suspected or diagnosed malignancy, after excising the tumour / ulcer, the specimen was sent for histopathological examination for confirmation and to corroborate the absence of margin involvement.

Adequate padding of the operated area was done followed by 'off-footing' cast / slab being applied. Sutures were removed between 12 – 14 days post-operatively. Patient were regularly followed up with advice of foot hygiene, off-footing with non-weight bearing footwear at least for 4 months.

Following factors were analysed - patients' age, patient's satisfaction with end result, and site & size of the tumours. Subjects in the study were followed up for a mean of 6 months or more. Considering the defect location, skin condition, and scarring, choice of unilateral or bilateral V-Y advancement flap was made without applying any algorithm for selection.

Statistical Analysis

Qualitative data was synopsised using percentage and frequency. Quantitative figures were summarized using standard deviation and mean.

Results

There were 14 women and 23 men with their ages ranging from 15 to 87 years (Tables 1 and 2). Mean age of the study group was 54.1 years with the youngest

being 15 years and eldest being 81 years old.

Table 1: Age distribution

Sl. No.	Age (In Years)	Number of Cases	Percentage
1	< 20	3	8.1
2	21 - 40	6	16.2
3	41 - 60	15	40.6
4	60 - 80	9	24.3
5	> 80	4	10.8
Total		37	100

Table 2: Gender distribution

Sl. No.	Gender	Number of Cases	Percentage
1	Male	23	62.2
2	Female	14	37.8
Total		37	100

The causes of soft tissue defects were diabetic ulcer in 12, malignancy in 11, pressure sore in 6, post infection ulcer in 4, followed by traumatic ulcer in 2 and ulcer as a consequence of lymphedema and rheumatic, 1 each. (Table 3)

Table 3: Plantar ulcer aetiology

Sl. No.	Aetiology	Number of Cases
1	Diabetic Ulcer	12
2	SCC/ Marjolin's	6
	Malignant Melanoma	3
	Basal Cell Carcinoma	2
3	Pressure Sore	6
4	Post Infection Ulcer	4
5	Traumatic Ulcer	2
6	Lymphedema Ulcer	1
7	Rheumatic Ulcer	1
TOTAL		37

The diameter of the ulcers ranged from 14 to 26 mm with mean of 19.3 mm.

21 cases had plantar ulcer in the right foot while 16 patients had in the left foot (Table 4)

In the foot, ulcer site was most commonly in the hind foot region (17), followed by forefoot (11), medial

Table 4: Foot laterality

Sl. No.	Foot Side	Number of Cases	Percentage
1	Right	21	56.8
2	Left	16	43.2
Total		37	100

part of the foot (7) and lastly in the lateral foot (2). (Table 5)

Table 5: Ulcer site

Sl. No.	Ulcer Site	Number of Cases
1	Fore Foot	11
2	Medial Foot	7
3	Lateral Foot	2
4	Hind Foot	17
Total		37

Mean diameter of the ulcer was 19.3 mm with the largest measuring 36 mm and smallest 13 mm

19 patients were operated under local anaesthesia, 9 patients were operated under ankle block, 7 patients underwent spinal anaesthesia and 2 patients had to be given general anaesthesia. (Table 6)

Table 6: Type of anaesthesia

Sl. No.	Type of Anaesthesia	Number of Cases
1	Local	19
2	Ankle Block	9
3	Spinal	7
4	General	2
Total		37

Unilateral V (-Y) advancement flap was employed in 26 cases and the bilateral V (-Y) advancement flap was used in 11 study cases. (Table 7)

Table 7: Number of V flaps used

Sl. No.	Number of V Flaps	Number of Cases
1	Unilateral	26
2	Bilateral	11
Total		37

Ample flap survival was accomplished in 36 cases with fractional flap loss in a single patient which

obligated a contralateral similar flap procedure to be performed. Wound dehiscence occurred in 3 patients, 2 of which required redo while 1 case was left to heal secondarily. No instance of complete flap failure, seroma, hematoma or infection occurred. Out of all the patients, 33 of them had excellent coverage and no recurrence of ulcer (or tumour) was seen in the follow-up period in them. Out of 4 patients with complications, 3 required surgery while 1 healed with secondary intention. (Table 8)

Table 8: Post-operative complications

Sl. No.	Post - Operative Complications	Number of Cases	
1	Flap Loss	Complete	0
		Partial	1
2	Wound Dehiscence		3
3	Infection		0
4	Recurrence		0
Total			4

Patient satisfaction on a scale ranging from 1-5, average score of satisfaction was 4.3/5. Least scoring (2) was given by a patient with partial loss of the flap and underwent VY plasty on the opposite side.

Discussion

A comprehensive assessment of an ulcer is essential and guides management. A sufficient account of ulcer characteristics, for instance, ulcer size, depth, appearance, and location on the foot, also provides for the mapping of progress during its management. Omitting this and underlying osteomyelitis often results in botched up surgical procedures. Meticulous debridement should be performed in all chronic wounds to remove debris and necrotic tissues. This improves healing by promoting formation of granulation tissue.

Leg and foot defect cover is challenging for plastic surgeons, particularly when they are located more distally as the donor site options for flaps are restricted. Regional flaps from lower leg and free flaps are often difficult reconstructive procedures to perform. Various procedures have been described for distal foot reconstruction such as adipofascial flaps, reverse flow flaps from leg, retrograde-flow medial plantar island flaps, retrograde dorsalis pedis or first dorsal metatarsal artery flaps. The ideal procedure for plantar ulcers is to recruit the surrounding alike tissue using local flaps to maintain weight bearing

characteristics of the volar region.

The VY advancement flap has the advantage of an excellent colour matching and texture harmony because of the proximity of the donor and recipient sites, thus providing superior aesthetic results. Also the fact that donor site can be closed primarily without requiring additional procedure for the donor site benefits the procedure choice. Certain modifications such as maintaining a relatively long, oblique flap moved by rotation in addition to the VY advancement facilitates extra mobility to the flap. The vascularity of the flap is reliant on the underneath dermal and subdermal plexuses. It is connected by a subcutaneous perforating artery. Also VY advancement flap is advantageous for placing the skin defect on the RSTL, thence, relieve suture line tension. This flap provides much less tension, thus, reducing the risk of hypertrophic changes and scar widening in the long term. Since it has a smaller degree of displacement and causes less tension, chance of wound dehiscence is way less. Also with resultant smaller dead space chance of postoperative complications like seroma and hematoma, is less. Also, there is a reduced amount of scarification of adjacent normal tissues. However another salient feature is preservation of sensation.

Disadvantage of this flap is however, tension, especially with larger defects owing to less mobility and risk of flap necrosis if not addressed. Since mid-portion of the defect is the farthest point away from the flap, it bears the point of maximum tension and the need for a tension free closure has been reiterated by many, another complication is trap-door deformity, also known as 'pin-cushioning', where the flap bulges out of its original position. Alternatively burying the pedicle deeper in the original will result in a more depressed appearing flap. Trap-door deformity usually resolves spontaneously or with the help of manual massage.

Our modification of the VY advancement flap provides the advantages of rapid healing, limited morbidity, and critical sensibility when executed properly. The goal of flap dissection is to disrupt all of the septae anchoring the skin to deeper structures while leaving intact the nerves and vessels which allows a relatively tension free flap advancement of the lucidum rich tough volar skin with septae limiting skin mobility. All these without the need to close in a 'Y' fashion. Also it was observed that the current modification mitigates the disadvantage

of formation of 'trap door deformity'.

In the post-operative phase, off-loading of the operated area is imperative for suture line healing and the most effective method for this and which is also considered to be the yardstick, is the non-removable total contact cast made of fast-setting fiberglass, enabling restricted activity. Routine foot examination, patient education, simple hygienic practices, provision of appropriate footwear, and prompt treatment of minor injuries can decrease wound dehiscence and ulcer recurrence, in the long run. Foot ulcer management remains a major curative challenge, however if managed effectively reduces the care burden in an efficient and cost effective way.

We conclude that when the above mentioned technique is properly executed, coverage of complex foot ulcerations by it represents a useful and reliable technique. This procedure has the advantages of excellent colour and texture matching and primary donor site closure.

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