

Another Dimension for the Choice in the Reconstructive Ladder, the Free Style Perforator Flap

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ABSTRACT

Background: The reconstructive ladder is an old concept that is familiar to all plastic surgeons. It is an arrangement of methods to reconstruct tissue defects from the easy to most complex one. With the advent of surgery, a lot of flimsy spots and difficulties showed up and yet showing up with the utilization of this old reconstructive stepping stool.

Objective: In this work, the authors will present another view of the reconstructive ladder that they incited that is more valuable to the patient than the bygone one.

Patients and Methods: The authors discussed six clinical cases. In each case, a travel study comparing the use of all the steps of the ladder to reach the best.

Results: The discussion of the clinical cases that included other reconstructive options demonstrated and affirmed the requirement for modifications in the reconstructive ladder.

Conclusion: The addition of the pedicled freestyle perforator flap would be a valuable update to the reconstructive ladder. The reconstructive Ladder is better viewed and organized as an order of beneficial priority to the patients rather than a classification of reconstructive options from simplicity to sophistication.

Key Words: Reconstructive ladder – Pedicled freestyle perforator flaps – Perforator flaps.

Evidence based Medicine: Level (V) study.

Ethical Committee: Approved study by ethical committee of Tanta Faculty of Medicine.

INTRODUCTION

The reconstructive ladder is not a nowadays concept, the oldest form of it was mentioned in the ancient Egyptian Smith papyrus 2600-2200 B.C (simple wounds should be approximated by (sutures), another wound should be wrapped by “away” stripes and gum while infected wounds should never be closed, instead, they are dressed by “honey and Sycamore leaves” [1]. Nowadays, the reconstructive ladder is familiar to all and every plastic surgeon. Although there is an advantage in

using the simplest reconstruction method to a given problem, simple is not always the more beneficial. The reconstructive ladder thus was subjected to several modifications. These modifications included adding rungs as negative pressure wound therapy, dermal Matrices, and perforator flap techniques [2]. Some authors recommended that the rungs should be considered as shifts in the surgeon's surgical skills empathizing that the difficulty of reconstruction method is related to the degree surgeon's skills [3]. Other authors added entirely new concepts like the reconstructive triangle [4], the reconstructive elevator1 and even proposed a reconstructive matrix with three axes representing technologic sophistication, surgical complexity, and patient-surgical risk [5]. Despite all the competing concepts, the reconstructive ladder continues to accept updating and to be the first concept that comes into the mind of any plastic surgeon when he or she faces a tissue defect. Some of the earlier versions of the reconstructive ladder is illustrated in Tables (1,2).

Table (1): One of the earliest forms of the reconstructive ladder [2].

Distant Flap
Local Flap
Skin Graft
Primary Closure

Table (2): The reconstructive ladder according to Janis et al., 2011 modifications [2].

Free Flap
Tissue Expansion
Distant Flap
Local Flap
Dermal Matrices
Skin Graft
Negative Pressure Wound Therapy
Closure by secondary intention
Primary Closure

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The freestyle perforator flap was introduced first as a free tissue transfer flap by the work of Mardini, Wei, and their colleagues. The freestyle concept entails choosing skin perforators used for free tissue transfer using a hand-held Doppler device [6,7]. As a natural process of the natural expansion of the scope of using the same concept, the pedicled freestyle perforator flap appeared and soon gained wide popularity as a method of reconstruction in all body parts [8-13]. The concept of pedicled freestyle perforator flaps was used to enhance the safety of well-known operations in plastic surgery like reduction mammoplasty [14]. Although these freestyle pedicled flaps could easily be categorized into the local flap category, it may be profitable to make finer distinctions. These flaps need more experience to dissect, elevate and inset if compared with a standard local flap e.g., V-Y advancement local flaps. Also, they need much

less experience if compared to a free flap and for sure their failure is less expensive. In the exemplary perspective, Latissimus Dorsi flap is given first consideration when approaching a huge defect in the classic way of thinking. Considering it as a perforator flap that devoted the need for microvascular surgery concepts nevertheless, the donor site morbidity may be a site of criticism. A successful freestyle perforator flap will fulfill the concept of the reconstructive balance suggested by Mathes & Nahai, 1997. The reconstructive balance denotes the importance of keeping in mind the balance between donor site(s) preservation and reconstruction of a defect [4].

Aim of the work: In this work, the authors will present another view of the reconstructive ladder that they incited that is more valuable to the patient than the bygone one.

Case Studies (Figs. 1-6)

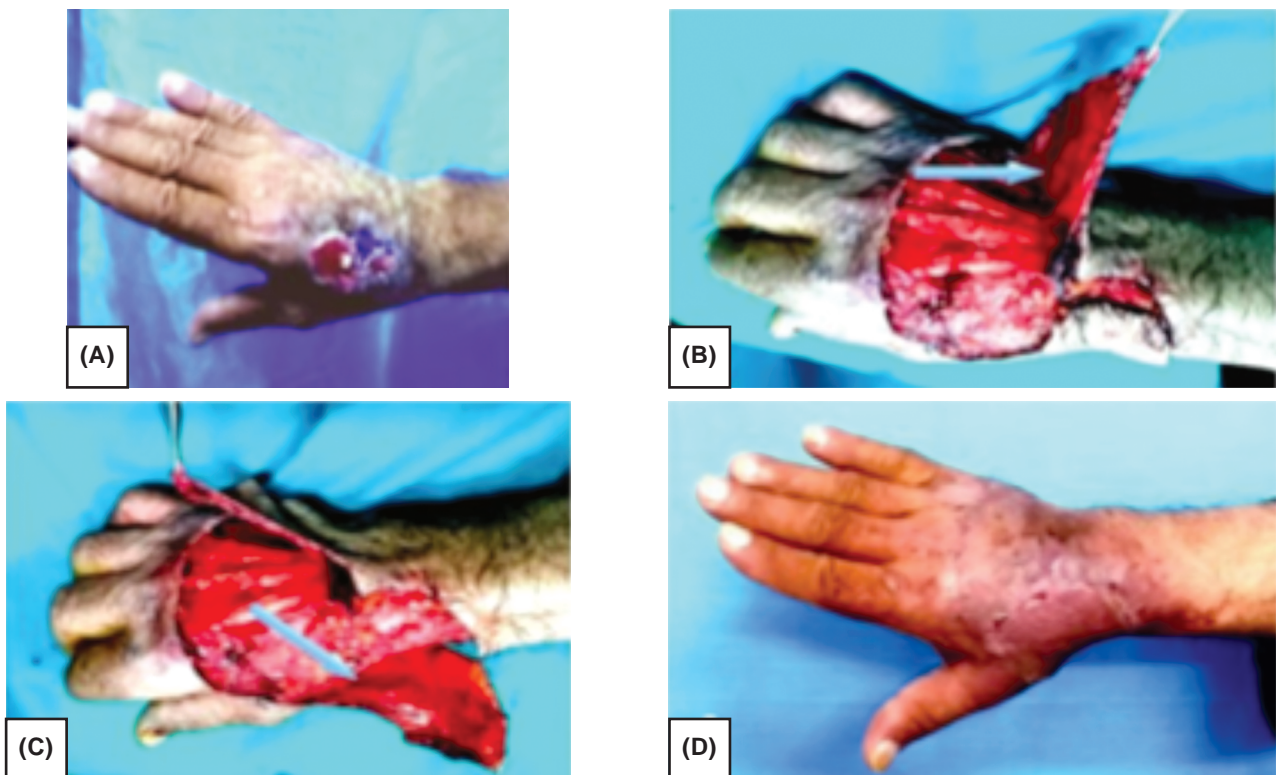


Fig. (1): Ulcerating squamous cell carcinoma in the dorsum of the right hand (first web space) in a 58-years-old man. (A): Pre-operative photos. (B,C): Intra-operative photo showing two freestyle perforator flaps elevation from the dorsum of the hand and distal forearm with arrows pointing at the perforators. (D): Early postoperative results.

A classic reconstruction in such a case would be simply a graft if there was no tendon exposure, but simple is not necessarily the best. Besides the donor site morbidity, which can be mutilating, grafts have tendency to contracture, poor color match. Lacking the pliability and gliding nature of the native skin of the distal forearm and dorsum

of the hand will not make them an ideal option. If there were any tendons exposed the choice would be a local, distant, or free flap transfer depending on the size of the defect. Local flaps would have limitations of Base/Length ratio as well as limited tissue yielding (if post excision defect is moderate to large as expected of the case at hand). Distant

and free flaps would give better tissue yield for a large defect, but with poor color and texture match, the donor site morbidity is significant as well as the cost of failure is considerable. Tissue expansion and negative pressure wound dressing are time-consuming and sometimes are not suitable due to the size, site, and nature of the defect. A pedicled freestyle perforator flap would yield enough tissues for moderate post-excision defects, and they would

provide the skin with excellent characters and color match. Therefore, the pedicled freestyle perforator flap is the first rung to put in mind in the modified reconstructive ladder. The next rungs would be the distant and free tissue transfer. They should be spared for large defects reconstruction, as a lifeboat if a freestyle perforator flap is impossible or simply failed.



Fig. (2): Fungating Squamous cell carcinoma in the neck infiltrating the deeper tissue including the submandibular salivary gland and the mandible of 56-years-old man. (A): Pre-operative photo. (B): Intra-operative photos showing the post-excision of the tumor, part of the mandible, the submandibular salivary gland as well as a plan for the flap. The Doppler-detected perforators were marked by an arrow and dots in the parasternal area). (D,E): Post-operative photo after moving a long pedicled freestyle perforator flap (Base Width X Length = 7cm X 34 cm). The distal part of the secondary defect was closed using a freestyle perforator flap from the axilla. While the proximal part of the secondary defect was closed primarily.

On reviewing available reconstructive options for this case, grafts with all their disadvantages and even local skin flaps are too thin and small-sized to fill such deep defects. Regional flaps are the second option. Classically, a medially based deltopectoral flap is the workhorse in this setting, but as an option, it is not free from disadvantages. It needs a base abroad that covers at least four intercostal spaces, this is a broad flap. This width will make the primary closure of the secondary defect almost impossible, and it needs grafting to the donor defect. Also, a second stage is usually needed to separate the pedicle and put the excess tissue back to the deltopectoral area. The patient will need two operations and will end with a graft donor site scar and grafted deltopectoral area added to the inevitable scarring of the deltopectoral area.

Through using the principles of the pedicled freestyle perforator flaps, A long narrow-based fascio-cutaneous flap was used (7X34cm). Therefore, primary closure was possible by the combination of skin undermining to the proximal defect and the use of another pedicled freestyle perforator flap from the region of the axilla to close the distal part of the defect. The narrow flap was inset in the neck. The use of a pedicled freestyle perforator flap spared the patient a graft donor site scar as well as a second-stage surgery. The fact that the final flap will be axially vascularized by the end of reconstruction will make it more tolerable to radiotherapy which can start earlier if it is needed for this patient. Tissue expansion and negative pressure wound therapy has a limited rule in this case due to anatomical site and pathology involved.



Fig. (3): Basal cell carcinoma in the scalp of a 69-year-old man. (A): Pre-operative photo. (B): Intraoperative photo showing post-excision defect. (C): Immediate post-operative photo showing reconstruction with single free-style perforator flap, a rotational flap with a base width of 4cm, and 12cm maximum length. (D): Late post-operative showing excellent scar camouflage. The post-operative Doppler assessment is shown in the supplementary clinical video, which revealed the patency of the chosen feeding perforator.

Grafting in such a case will have a lot of disadvantages. It will leave the patient with hairless and depressed graft in the occipital region, as well as the scars morbidity at the graft donor sites, which have unpredictable outcomes. A local random pattern rotational flap will not rotate enough to cover 4 X 5cm post-excision defect; thus, two flaps may be needed. The success of this classic approach will depend on the random vascularity of two flaps which in our opinion increases the risk of vascular insufficiency. The use of a second flap will add more scars in the scalp either in the bald area of the parietal region or the frontotemporal area according to the sites of the chosen flap. Tissue expansion after excision and grafting is time-consuming and adds stages for the reconstruction. The design of scalp flaps as freestyle perforator flaps especially in the vicinity of muscles and/or named arteries is of great advantage. To this patient, for example, replacing like with like during reconstruction, more reduction of the base width was achieved allowing single, relatively long, wide, and a narrow-based flap to rotate and cover the defect with preserved flap viability and superb aesthetic outcome. The post-operative scars are shown in the supplementary video. In our opinion,

pedicled freestyle perforator flaps should be the first rung to come to mind in cases like this, and skin grafts as an option should be spared to patients with systemic morbidity who cannot tolerate flap surgery and/or in cases with doubtful free excision margins.



Fig. (4): Basal cell carcinoma affecting the nasal tip, dorsum, and sides in a 74-year-old patient. (A,C,E): Pre-operative photo and initial planning. Arrows are pointing to the sites of the perforators which were marked by blue dots). (B): Preliminary planning. (D,F): Late post-operative pictures.

Classically, on review of this case with the expected size and depth of the post-excision defect, one would consider an oblique forehead flap. However, this choice would necessitate an overt oblique scar in the forehead with primary closure or grafted forehead, and an unpredictable scar at the donor site. A bilateral infra-orbital pedicled freestyle perforator flaps solved the problem in a single stage and with neat scars at the nasolabial folds and excellent aesthetic outcome. Grafts are not an option in this case as the parts of the bones, as well as nasal cartilages, were exposed after tumor excision beside the “patched” look of the nose if grafting was successful. Local flaps would never yield enough skin for the reconstruction of this defect. In the authors' opinion, the rung of pedicled freestyle perforator flaps should be the first rung to think of in the reconstruction of such a case.

The analysis of this case revealed that during the first surgery, the surgeon used a glabellar flap in an attempt to avoid the long overt scar, the two stages, and the potential need for graft in the forehead. The forehead flap is considered the classic reconstruction workhorse flap in this patient case like that. The choice of the glabellar flap which

yields a small amount of skin compelled the surgeon to be over-conservative during excision thus incomplete excision of the tumor and therefore, recurrence occurred. If a unilateral pedicled freestyle perforator flap was chosen, it would cover a wider surface area and would allow the surgeon to do wider excision as well as avoiding all the disadvantages of the oblique forehead flap. The donor site scar of the pedicled freestyle infra-

orbital perforator flap is nicely hidden in the nasolabial fold. Whether the primary or recurrent case, grafts are cosmetically poor regarding their donor and recipient site, they cannot cover these complex defects and a random local flap will not yield enough tissues for reconstruction. Therefore, the pedicled freestyle perforator flaps should be the first rung of the reconstructive ladder to come in mind in this kind of cases.

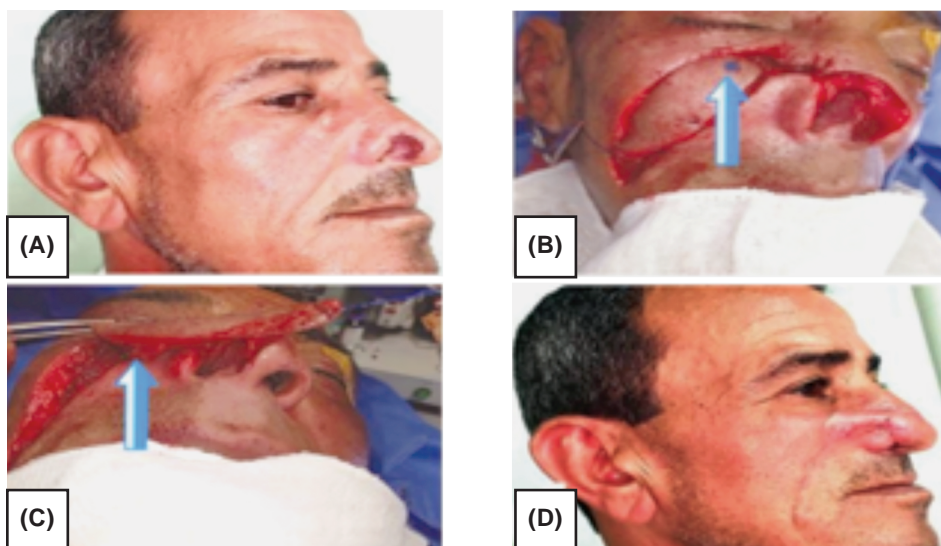


Fig. (5): Recurrent basal cell carcinoma invading right ala and tip of nose in a 55-year-old man. One year ago, glabellar flap reconstruction surgery was done for same lesion, but recurrence occurred. (A): Pre-operative view. (B,C): Intra-operative view showing post excision defect and unilateral infra-orbital pedicled freestyle perforator flap and site of Doppler-detected chosen perforator was marked by a blue dot and pointed at by arrow (D): Late post-operative view after reconstruction of the defect.

Fig. (6): Recurrent basosquamous cell carcinoma (for the second time) invading the ear and the lateral cheek in a 65-year-old man. (A): Pre-operative photo. (B): Intra-operative photos showing the post-wide excision defect which included part of the parotid gland, the periosteum of the zygoma. (C): A pedicled freestyle perforator flap elevation from the neck with artery forceps and an arrow pointing at the perforator (D): Immediate post-operative defect. (E): Post-operative photo.



On clinical review of this case, according to the traditional reconstructive ladder, the ulcer should be excised, and reconstruction performed using a skin graft, which is a good option if the surgeon doubts the excision margin. The second reconstruction tool in the same ladder was supposed to be, the local flaps, which was not a good option as the excision of recurrent tumors should be wide and aggressive. The choice of reconstruction with local flaps with its relatively small tissue might compel the surgeon to take a conservative attitude during excision and so re-recurrence is almost inevitable. The choice of pedicled freestyle perforator flaps in the third reconstruction offered a single-stage operation, fulfill the concept of replacing like with like, capable of enough tissue yield for a 7 X 8cm defect to finally get the desired tumor-free surgical margins in this case. Hair in the neck skin will allow concealing a good part of the postoperative scar. The Axial blood supply of the used pedicled freestyle perforator flap will make it more tolerable to radiotherapy which was started once wound healing allowed. Unfortunately, the branches of the facial nerve had to be sacrificed to eradicate the tumor. Keeping of the pedicled freestyle perforator free flap in the same rung with local flaps may be the cause that led to overlook the former's potentials in cases like this case, in particular as the surgeon may coin both types as local flaps following the older version of the reconstructive ladder thus, maybe, he/she was trying to avoid the rung of multi-staged regional flaps or the rung of free flaps by using local flaps. This case in the author's opinion denotes the need to separate pedicled freestyle perforator as an independent rung in the reconstructive ladder so as not to be forgotten or to be overlooked.

DISCUSSION

Despite all the competing concepts and the claims of being creativity hampering¹, the reconstructive ladder continues to be the first concept that comes to mind of a most plastic surgeon when he or she meets any kind of a tissue defect. The main cause of this stability throughout centuries comes from the fact that the reconstructive ladder is a concept that accepts updating. In the authors' opinion, other concepts like a reconstructive elevator, reconstructive balance, and reconstructive matrix serve as tools that help the surgeon to choose between the rungs of the reconstructive ladder. In its current form, the reconstructive ladder serves only as a classification of reconstructive options from the simplest to the most sophisticated techniques. In the authors' opinion, the order of the rungs in the reconstructive ladder, in its current

form does not indicate any kind of priority of these rungs over the other rungs. It needs no saying that the more sophisticated the method of reconstruction the more is the cost of failure. However, factors like risk versus benefit factors, functional and aesthetic factors, donor site morbidity, surgeon's experience, presence of a lifeboat reconstruction, and cost of failure should be put in mind while the decision is being made regarding choosing the reconstructive method and at this point comes the role of the elevator, triangle, the matrix, and the balance. In the authors' opinion, the freestyle perforator flaps should have a rung in the reconstructive ladder. Since the classic reconstructive ladder rungs are classifying the reconstruction options according to difficulty, the freestyle pedicled perforator flaps should not be simply added to e.g., Z-plasty, V-Y flaps as a local flap. The later flaps are random in their vascularity, offer a lesser number of tissues, and sure technically easier than pedicled freestyle perforator flap. On the other hand, the freestyle is sure to be less technically demanding if compared to free flaps of any kind. Pedicled freestyle perforator flaps cannot be put in the same rung of distant flaps because distant flaps are more technically demanding. The pedicled freestyle perforator flaps can be viewed as a low-risk low demanding technique as it needs only a Doppler. Doppler is a safe, easy to obtain and inexpensive device and it is easy for a junior surgeon to master its use. Poor training on Doppler means that the surgeon will miss the perforator but sure will not harm the patient. A failure of a pedicled freestyle perforator flap is less devastating if compared to a distant flap or a free flap but it is more than the cost of a failure of a local flap as the freestyle perforator flaps is almost always are formed of larger amounts of tissues and have a larger surface area as well as the fact that pedicled freestyle perforator flap would cause loss a perforator that can be potentially used if a free flap is going to be used later. In the authors' opinion, it is worth mentioning that in practice there is no such thing as absolutely simple or absolutely safe technique. For example, split thickness grafting needs proper training on using graft knives. Poor training on graft knife can lead to deep structure injury while harvesting a graft. In the authors' opinion, the addition of an independent rung in the reconstructive ladder for the Pedicled freestyle perforator flaps (Table 3) will add it as a non-forgettable reconstructive option that has the following advantages:

- The addition of some techniques like the propeller technique added to its mobility and ease of in-setting.

- Perfect color match.
- Reported success rate 93% which can even be improved with training as reported by D'Apra et al., 2011 [15].
- Keeps the secondary scarring, secondary defects, cosmetic morbidity to the area of the primary pathology if successful which fulfills the concept of The Reconstructive Balance reported by Mathes & Nahai, 1997 and the concept of Aesthetic reconstruction reported by Elmelegy et al., 2020 [12].
- There is still a place for a lifeboat if a pedicled freestyle perforator flap fails using higher rungs on the reconstructive ladder.
- Relative technical ease and shorter curve of training for the surgeons.

Table (3): The rungs of the reconstructive ladder arranged according to simplicity as suggested by the Authors.

Free Tissue transfer
Tissue Expansion
Distant Flap(s)
Pedicled Freestyle Perforator Flap(s)
Local Flap(s)
Dermal Matrices
Skin Graft(s)
Negative Pressure Wound Therapy
Primary closure
Closure by Secondary Intention

In the current era of modern reconstructive surgery and the increased patient demands and expectations, simple is not always the best and reconstructive surgeons should choose the best technique for the patient rather than the easiest technique to be done. Therefore, in modern practice, the surgeon can use free tissue transfer as a first choice. Another example, in many reconstructive operations in the authors' department, pedicled freestyle perforator flaps were used successfully as a first reconstructive option if primary closure was not suitable.

Conclusions and Recommendations:

The addition of an independent rung for a pedicled freestyle perforator flap would be a valuable update to the reconstructive ladder. The reconstructive Ladder better be viewed and re-arranged as an order of the beneficial priority or advantage rather than a classification of reconstructive options from the simple towards the most complex. The authors suggested a model of such modification, and it is the same form of the reconstructive ladder they use in their public hospital practice.

Conflict of interests:

The authors of this work have no conflict of interest of any kind.

Compliance with Ethical Standards:

All the steps performed in this work that involved human participants were in accordance with the institutional and national research committee and with the 1964 Declaration of Helsinki and its later amendments or ethical standards. All principles of ethical and professional conduct have been followed. Informed consent was obtained from all patients included in this study. All patients signed informed consents for the surgeon and the use of their clinical data in scientific publishing. An additional consent for scientific publishing of photos that may show patients' uncovered faces was signed by all patients.

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