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The Keystone Perforator Flap for Tension-free Closure of Defects in the Back

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Abstract

The tension-free closure is of paramount importance in the reconstruction of skin and soft tissue defects on the human body. Plastic and reconstructive surgery poses a great variety of reconstructive options. However, in specific areas like the back region with thick, inelastic dermis and limited mobility of the surrounding tissue this could be a difficult endeavor. On the other hand, the technique easier for both the surgeon and the patient is selected where faster and better outcome is expected to be achieved. Among the reconstructive possibilities, nowadays the keystone island perforator flap differs as a relatively simple and quite reliable surgical technique to defect closure. In the present article a brief retrospective clinical study of the application of the keystone flap conception is made encompassing patients with skin and soft tissue defects of the back. Clinical records and photo documentation of 14 patients reconstructed with keystone island flaps are recruited and revised. From the total patients there was only one minor complication-delayed wound healing in a smoker male patient. In this clinical series the keystone perforator island flaps have shown to be a sophisticated and relatively easy option for tension-free closure of residual defects in the dorsum after both tumor excision and traumatic injuries. This concept gives reliable and reproducible results in both anatomical and aesthetic sense.

Keywords

Keystone perforator flap; Perforasomes; Local plasty; Tension-free closure

Introduction

Tension-free closure has paramount importance in the reconstruction of skins and soft tissue defects on the human body. The back region is a specific one because it has the thickest non-glabrous skin in the human body with low elasticity and dense fibrous septae to the underlying tissue especially close to the midline and basically over the spine [1]. That's why closure of skin defects following excision of skin cancers or traumatic injuries in this region of the trunk could be particularly difficult, somehow non-reliable and non-effective considering the tension in the surgical scar. Talking about the effectiveness, the local flaps have shown to be a preferable reconstructive option because they have better color and contour and are associated with significant reduction of the donor site sufficient tissue mobility and elasticity are the most important issues to consider at the time of harvesting any morbidity [2]. However, the kind of local flap especially on the back.

Among the reconstructive possibilities with local tissue, nowadays the keystone island perforator flap seems to be a relatively simple and quite reliable surgical technique for defect closure. This conception consists of taking skin and superficial fascia in a keystone pattern adjacent to the defect that needs to be covered [1,3-6]. This technique is based on the most contemporary knowledge of the vascularization and three-dimensional vascular architecture of the skin and soft tissue overlying the bones- the so called angiosomes and perforasomes concepts [7-9].

The keystone perforator island flap was initially described by Behan [3] as a trapezoidal-shaped flap which consists of two conjoined V-Y island. The vascular supply is supported by the subcutaneous vascular network and is dependent on fascial and muscular perforators [6]. The keystone flap conception encompasses four types of local island flaps (Figure 1) which could be applied depending on the location and dimensions of the defect to be repaired and the vascularity of the area [3].

The aim of this brief clinical study is to demonstrate the effectiveness of the keystone perforator island flap for closure in a tension-free fashion of full thickness skin defects on the back with engagement of underlying fat and superficial fascia.

Patients and Methods

A retrospective analysis based on the clinical records and photo-documentation was made recruiting patients of the authors' practices with skin and soft tissue defects on the back for a period of four years. Demographic and medical information on the patients was collected, including age, regular habits, comorbidities, current and past medication,

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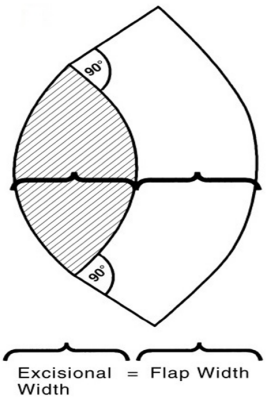
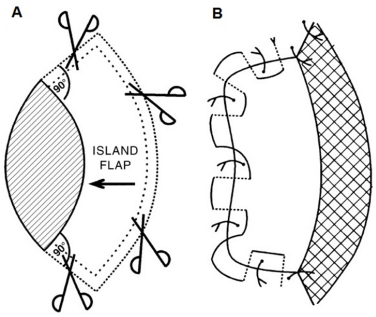
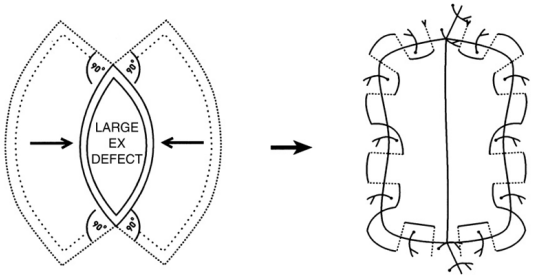


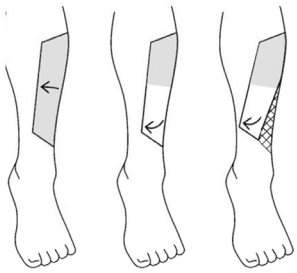
Keystone flap type I: design of the flap for closing a fusiform defect- the trapezoidal shaped island flap is tailored along the side of the defect with 90° angle at the limits of flap



Keystone flap type II: when greater mobility is needed a division of the deep fascia along the outer curvilinear line is performed – keystone flap type IIA. When excessive tension is present, the secondary defect may be closed by using a skin graft- so called keystone flap type IIB



Keystone flap III: for considerably larger defects double opposing keystone flaps could be harvested in order to exploit maximum laxity of the surrounding tissues



Keystone flap IV: it is a rotational keystone perforator flap and a skin graft is applied for closure of the secondary defect

Figure 1: The four different types of keystone flap [3].

diagnosis, size of the defect to be reconstructed, type of the keystone flap and post-operative follow up. As exclusion criteria bone penetration of the malignancies and partial thickness of the defects were selected.

Both written and verbal consent was obtained from all the patients for the surgical procedure, possible risks and complications, and the utilization of the patients' personal data and photos.

The patients were operated under general anesthesia or local anesthesia with or without sedation. In all the cases a local infiltration solution containing 1% lidocaine and 1:100000 epinephrine was applied. All the reconstructions were performed in one stage with keystone perforator island flap recruited from the surroundings of the defect. For the surgical wound closure skin stapler and monofilament sutures were applied. The follow-up protocol for all the patients was the same as follows: for the oncology patients a 6-month follow-up was established by the plastic surgeon who has performed the reconstruction; afterwards an oncologist or dermatologist has continued the follow-up process. For non-oncology patients a minimal follow-up of 1 month was made by the plastic surgeon.

Results

A total of 14 patients with age range between 46 and 78 (mean age 61,86 y) (Table 1) were operated for the selected period of the study. In 12 of them a skin cancer was the reason of the reconstruction, being the basal cell carcinoma (BCC) the main type of cancer (n=8). One of the cases was intervened because of a skin melanoma *in situ* (MM) (n=1). The rest of the patients presented either squamous-cell carcinoma (n=3) or traumatic lesions (n=2) as a reason for the reconstruction. In the series the post-excisional defects vary between 1.8 cm and 5.8 cm. All the defects were reconstructed in a single stage procedure by applying the keystone island perforator flap conception as shown in the (Table 1): the most frequently applied flap was the type IIA (Figure 2) (n=9), followed by type III (n=3) and type I (n=2) respectively. The postoperative period was uneventful and all of the patients were discharged from the facility on the same day or on the day after the surgery. In one of the patients, 63-year-old male smoker, a delayed wound healing was registered and solved by local therapy only. In the rest of the cases the surgical wounds hilled by primary intention and the skin staples and stitches were removed between 12th and 21th postoperative day. Histology study of the malignant lesions confirmed the radicality in tumor removal in all the 12 patients affected by skin malignancies.

No	Age	Sex	Diagnosis	Type of flap	Complications
1	71	Male	BCC	Type IIA	No
2	58	Female	BCC	Type I	No
3	61	Female	BCC	Type IIA	No
4	52	Male	TD	Type III	No
5	69	Male	BCC	Type IIA	No
6	78	Male	SCC	Type III	No
7	47	Female	MM	Type IIA	No
8	63	Male	BCC	Type IIA	Delayed wound healing
9	67	Male	BCC	Type I	No
10	53	Female	SCC	Type IIA	No
11	72	Male	BCC	Type III	No
12	70	Male	BCC	Type IIA	No
13	59	Female	SCC	Type IIA	No
14	46	Male	TD	Type IIA	No

Table 1: Patients included in the study-BCC: Basal-cell carcinoma; SCC: Squamous-cell carcinoma; MM: Malignant melanoma; TD: Traumatic defect

(A) 69-year-old man with pigmented lesion on the back interpreted as a morpheaform BCC; **(B)** Keystone flap type II was designed for tension-free closure of the eventual post-excisional defect; **(C)** Keystone flap type IIA was harvested and after division of the deep fascia along the outer curvature of the flap it is being advanced to close the defect; **(D)**The flap sutured in place under minimal tension which is equally distributed over the entire reconstructed area; **(E)** Postoperative outcome at 1 month: a hyperpigmentation is still present but no contour deformity is registered.

Figure 2: Clinical case No. 5

In all of the cases full anatomic and aesthetically acceptable reconstruction was achieved and 100% of the patients of the present study were satisfied by the final result.

Discussion

One of the basic principles of the defect closure in plastic and reconstructive surgery is restoration of the skin and tissue continuity under minimal tension [10]. Minimizing the tension in the scar is a main factor for uneventful healing and good morphological, functional and aesthetic outcome. The back is the area of the human body which has the thickest dermis with extremely low elasticity. On the other hand, it is a difficult site for direct auto-observation form the patient and therefore skin and soft tissue malignancies are usually more advanced at the time of the diagnosis. This fact usually determines the need of more extensive excisions which leave behind complex three-dimensional post ablative defects to be repaired. Direct closure could be possible but at the price of long disfiguring scars with increased risk of wound dehiscence and contour deformity especially when dealing with highly aggressive tumors [1]. Considering the wound dynamics and trying to minimize the wound tension Behan et al published in 1995 their work on the Bezier or French curve flap [11]. It was introduced to deal with elliptical defects that are not close by direct apposition. The keystone flap design is a relatively simple and at the same time excellent solution for defects over the total body surface area. We have applied successfully this concept in closing defects on the limbs and other areas of the human body where a paucity of surrounding tissue and low elasticity and mobility were present [12]. Analyzing the results of the present study we were able to confirm our previous clinical findings and the findings of others as well [1,3-6] that the keystone perforator flap concept is a reliable solution where tension-free closure is needed. In our study the most frequently applied flap was type IIA which is typically used for larger areas of reconstruction up to 5 × 10 cm approximately, located over the muscular compartments where the deep fascia over the muscular compartment is normally divided along the outer curvature of the keystone flap in order to permit further tissue mobilization (Figures 1B and 2C).

In the present clinical series there was only one case with delayed wound healing in a patient who smoked more than 40 cigarettes per day. It has been shown that smoking has a well-established negative effect on the wound-healing process no matter how tension-free is the wound closure because of the hypoxia and tissue ischemia [13,14]. The above mentioned patient had very bad compliance and didn't stop smoking neither before nor after the surgical intervention. Nevertheless, his minor wound complication was solved with conservative local treatment consisting in frequent dressing changes and no further surgery was needed.

Conclusion

In this clinical series the keystone perforator island flap concept has shown to be a sophisticated and relatively easy option for tension-free defect closure on the back. The knowledge of the vascular supply of the skin and soft tissue is of paramount importance for the proper design and execution of this technique.

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