

# The Use of Keystone Flap for the Reconstruction of Skin Defects

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## Abstract

**Background and objectives:** Skin graft and various flaps are used to cover defects; available options have different patterns of blood supply, aesthetic outcome, donor area morbidity, surrounding soft tissue availability, operative time duration, the need for microsurgical expertise and long term complications. The aim of this study is to assess reliability and versatility of keystone flap for the reconstruction of the skin defects.

**Methods:** Reconstruction of skin defects by keystone flap were done in plastic surgery department between (January 2018- May 2020), records of patient's age, and cause of the defect, size, flap outcome and complications are documented. to study the ability of the flap to cover the skin defect and its long term survival.

**Results:** Nineteen patients underwent reconstruction, age was ranging from two days to seventy-five-year-old with mean age 37.5 years, twelve were males and seven were females. Size of the defect ranged from (0.5 cm x 1 cm) to (9 cm x 7 cm) with mean defect size 31.75 cm<sup>2</sup>. Seven flaps in head and neck, five in the trunk, five in lower limb and two flaps in upper limb. All flaps were successful in covering the defects, no partial or total necrosis with minor complication in two patients.

**Conclusions:** Keystone flap is a reliable flap with excellent survival rate, versatile and can be used for skin defects in different regions of the body with low complication rate, easy technique for learning by surgeons and have short operative duration with good cosmetic outcome.

**Key words:** Keystone flap, Reconstruct, Skin defects.

## Introduction

The repair of skin defects remains challenging when there is inadequate local tissue. Split thickness skin grafts are used to close such defects after removal of skin lesions but have less skin quality with poor aesthetic outcome. The free flap and local propeller flaps result in excellent function but there is risk of total or partial flap loss plus the long duration of the procedure. The keystone design perforator flap, described by Behan in 2003 can be used for the reconstruction of skin defects of variable sizes.<sup>1</sup> Keystone has a curvilinear trapezoid shape which depends on its bed for blood supply mainly from fascial and muscular perforators.<sup>2</sup> It can be designed as unilateral or bilateral for larger fasciocutaneous defects. The shape of

keystone adheres to the wound edge providing structural support for coverage employing double V-Y advancement.<sup>3</sup> The keystone flap can be applied easily in surgical procedure consuming short time, and promptly fitted to the defect area. Approximating the lateral V-Y flaps narrows the defect and creates central redundancy, allowing better mobility in the perpendicular direction and distributing tension equally.<sup>4</sup> Keystone flap classified into four types: Type I in which the deep fascia is not divided and usually used for defects up to 2cm in width. Type II in which the deep fascia is divided and this type further subdivided into type IIa in which the secondary defects closed primarily and type IIb

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which requires skin graft to close the secondary defect. Type III which used double keystone flaps to recruit local tissue as large as possible to cover large defects (5 x 10cm). Type IV this type involves undermining of a part of the flap either proximally or distally and raised on subfascial plane, undermining can reach up to two thirds of the flap surface area. Secondary defects always require skin grafting.<sup>3</sup> In the head and neck, invasive tumor resections always result in large defects which requires coverage with free flaps, keystone can provide a reliable and simple alternative.<sup>5</sup> In burn injuries deep dermal burns and full thickness burns are treated with excision and skin grafting which results in different color match, contour deformity and contracture. Keystone flap can be a better option for small size full thickness burns with much higher aesthetic outcome.<sup>6</sup> For posttraumatic lower limb reconstruction keystone flap is gaining popularity and is performed for gustilo II and gustilo III with open fractures for proximal, middle and even distal thirds of the tibia with exposed bone. The blood supply of the flap comes from perforators from fascia

### **Patients and methods**

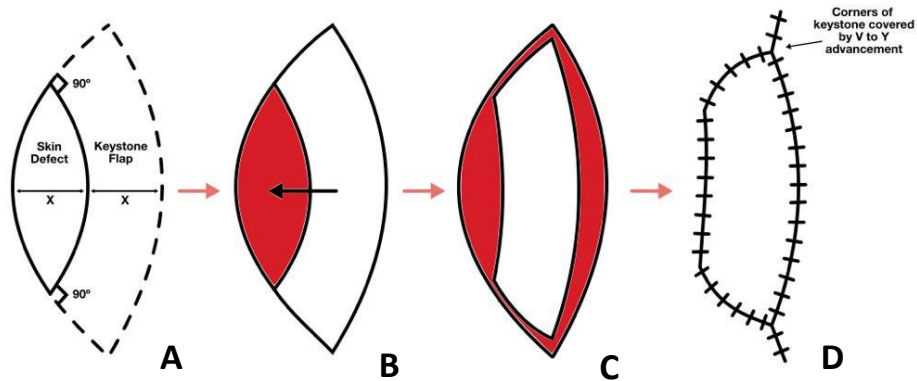
This is a prospective observational case series study in which we interviewed nineteen patients who underwent a keystone flap for the closure of skin defects in any part of the body, the study was conducted in two settings namely Rizagary hospital and Rojawa emergency hospital in the period between January 2018- May 2020, full written and verbal consents were asked for and granted by all cases both for undergoing the study and publishing their photos after which all were sent for routine blood investigations, viral screening, complete blood count and some patients required further investigations for the fitness for anesthesia. Inclusion criteria were cases with skin defects that cannot be closed primarily while cases with scar and previous irradiation at the site of flap

and muscles and also it can avoid subcutaneous dissection which is performed in bipedicle flaps.<sup>7</sup> Covering wounds of greater trochanter pressure sore with perforator flap or fascia lata flap commonly used but these have risk of pedicle kinking and donor area morbidity, keystone flap applied successfully for cover greater trochanter pressure sore in paraplegic patients.<sup>8</sup> Skin defects around the joints represent a reconstructive difficulty, the plan to cover such wounds should handle the tension around the joint due to the mobile nature of these areas, and keystone flap can be used around the joint with cosmetic and color appearance close to adjacent tissues.<sup>9</sup> Keystone flap can be modified that a skin bridge can be left intact along the greater arc to preserve some lymphatic and blood vessels, also it can prevent a fully islanded flap to reduce the pin cushioning effect.<sup>10</sup> Donor area of radial forearm flap defects can be closed with keystone flaps without the need for additional skin graft.<sup>11</sup> The objective of the study is to assess the reliability of keystone flap to cover skin defects in different regions in the body.

markings were excluded from this study. The flap was done to these defects which were caused by trauma, pressure sore, myelomeningocele or tumor excision defects. These wounds or defect weren't possible to be closed directly as such direct closure would have exerted a negative impact on the function or anatomical landmarks in the concerned body area. Operations were performed under both local and general anesthesia according to size of the defect and the ability to control hemostasis, some patients required preparation of the wound by debridement until they become ready for definitive closure by the keystone flap. Design of the flap drawn as two curvilinear lines, one is the edge of the defect and the other one which can be called also the greater arc, the distance between them is equal width

of the wound or the defect, a curvilinear incision is made parallel to the defect with two incisions at a 90-degree angle at either end of the defect which meet the curvilinear line as shown in Figure (1). We suture the top of the curvilinear edge of the flap with the parallel skin edge then the rest of the flap sutured to the Surroundings. Suturing is done in single or double layer depending on the depth and

thickness of the skin edges. After closure the wound is cleaned and dressed, most of the patients discharged to home unless the defect is large or the flap needs monitoring inside the ward. Sutures are removed after one week then follow up done every week until one month then every month until 6 months. This study was approved by the ethical committee of Kurdistan Higher Council of medical specialties.

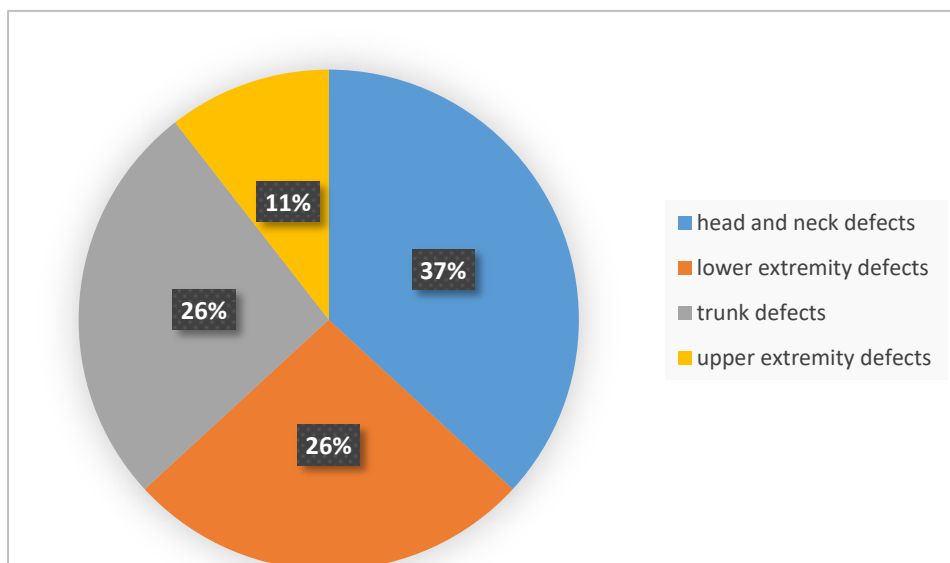


**Figure (1):** Scheme of Keystone flap. **A:** marking of donor area **B:** Incising the flap edges **C:** Mobilization of the flap to cover the defect. **D:** Suturing of the wound.<sup>12</sup>

### Results

We have included nineteen patients to undergo reconstruction of skin defects with keystone flap, the range of patients age is from is from two days to 75-year-old, size of the defect ranged from (0.5 x 1

cm) to (9 x 7 cm). Twelve patients were males and seven patients were females. The distribution of flaps applied in different areas is illustrated in Figure (2).



**Figure (2):** Skin defect reconstruction according to anatomical regions.

As we referred to in the introduction, keystone flap is classified into four types.

We applied all four types in this study, their description and the number of

patients in whom they were used is manifested in Table (1). We have not used

skin graft to close donor area in any case.

**Table (1):** Types of keystone flaps used

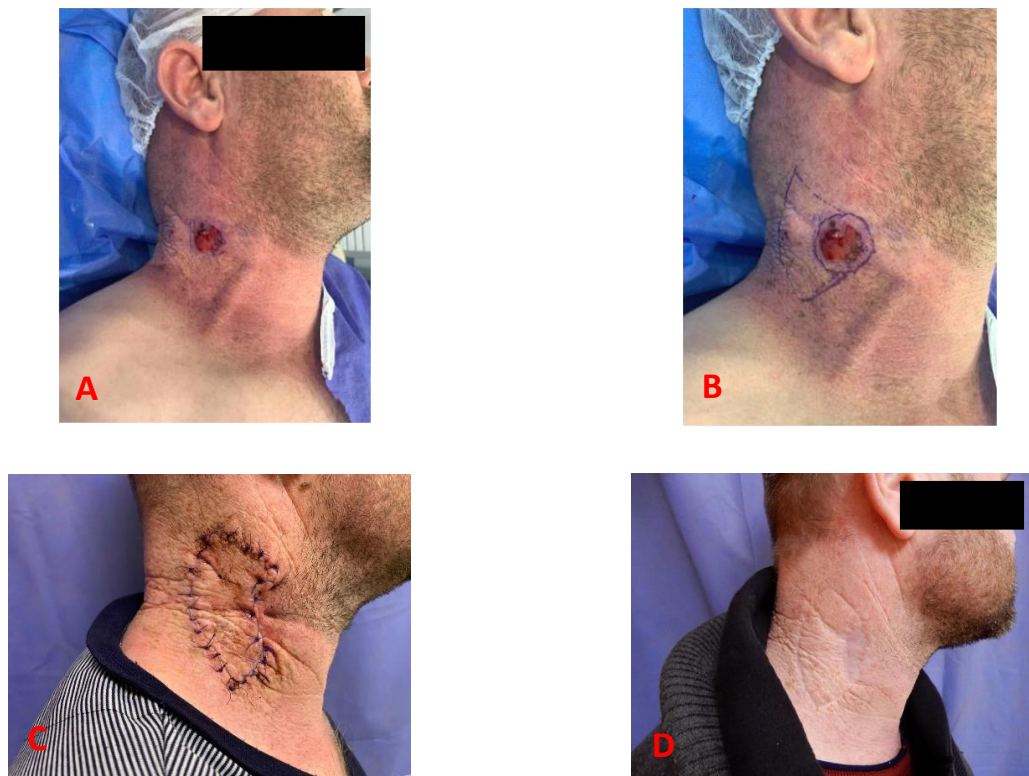
Classification of keystone flap	Number of cases
Type I: Standard flap design without division of deep fascia	
Type II: The deep fascia is divided to enhance mobilization.	
Type III: Double keystone flaps are designed to facilitate closure	
Type IV: Up to two- thirds of the flap is undermined.	
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Details regarding patient’s site and size of the defects are shown in Table (2). In the follow up period ranged between six months to one year, there was no total or partial necrosis of the flaps with ability to cover defects in all cases Figure (3, 4 and 5). We have minor complications in two

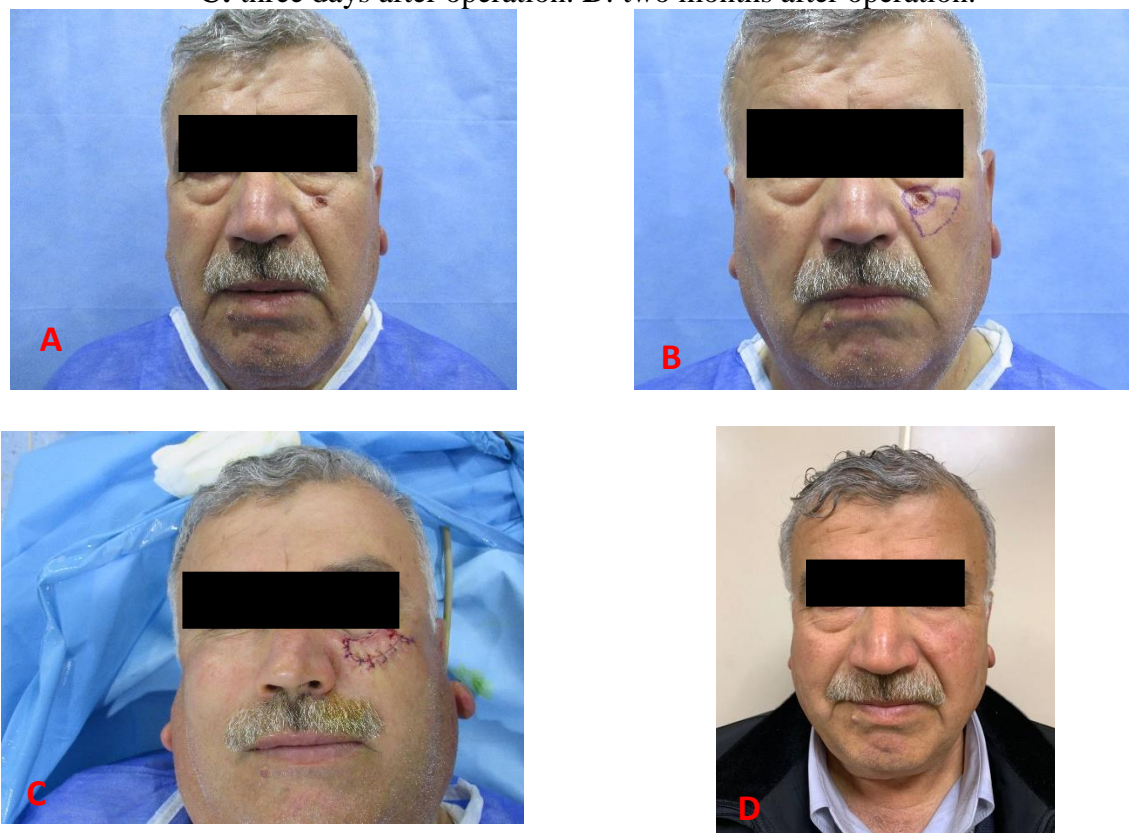
patients, one of heel reconstruction and the other one the trochanteric reconstruction developed wound dehiscence. Both have been treated conservatively and closed after three weeks and six weeks respectively.

**Table (2):** Patients’ data in the study

Case	Sex/age	Site	Size
1	Male/50 years	Sole of foot	2 cm x 2 cm
2	Male/75 years	Cheek	4 cm x 3 cm
3	Female/67 years	Nose/inner canthus	1 cm x 1 cm
4	Female/47 years	Nose/medial canthus	1 cm x 1 cm
5	Male/3 days	Lumbosacral myelomeningocele	9 cm x 7 cm
6	Female/16 years	Proximal phalanx-middle finger	0.7 cm x 1 cm
7	Male/17 years	Distal tibia	4 cm x 2 cm
8	Male/60 years	Cheek	1.5 cm x 1.5 cm
9	Male/42 years	Ischial pressure sore defect	5 cm x 6 cm
10	Male/6 days	Lumbosacral myelomeningocele	6 cm x 5 cm
11	Male/33 years	Neck lesion	3 cm x 2.5 cm
12	Male/46 years	Trochanteric pressure sore	7 cm x 7 cm
13	Female/10 years	Heel –sole of the foot	1.5 cm x 2 cm
14	Male/30 years	Heel-sole of the foot	2 cm x 2 cm
15	Female/64 years	Cheek	2.5 cm x 2 cm
16	Male/17 years	Upper Thigh	10 cm x 6 cm
17	Male/42 years	Index finger-distal phalanx dorsally	1 cm x 1 cm
18	Female/5 days	Lumbosacral myelomeningocele	5 cm x 5 cm
19	Female/54 years	Medial upper eyelid defect	0.5 cm x 1 cm



**Figure (3):** A: patient with basosquamous cell carcinoma. B: Marking of the flap. C: three days after operation. D: two months after operation.



**Figure (4):** A: patient with basal cell carcinoma. B: preoperative marking. C: immediately after operation. D: after one year.





**Figure (5):** A: patient with pressure sore on the heel after a session of debridement. B: preoperative marking. C: after one year from the operation.

## Discussion

Keystone flap first described by Behan in 2003 is a random pattern flap with two V-Y flaps at an angle design used as a locoregional advancement flap.<sup>2</sup> Keystone flap proved to be reliable for various complex defects with simple technique, short operation duration, reliable blood supply and predictable flap survival.<sup>13</sup> Out of the nineteen cases there was no partial or total necrosis of any flap and this justifies reliability of the flap, similar results have been achieved in previous study,<sup>2</sup> the high success rate of the flap is due to dual blood supply both subcutaneous vascular network and perforator vessels from underlying muscle or fascia.<sup>2</sup> We have two patients developed wound dehiscence, first was trochanteric pressure sore which may be attributed to incomplete debridement of non-healthy tissue and the second one was keystone flap for heel reconstruction for a chronic ulcer and the reason for dehiscence could be The tension, in both cases there were no necrosis or any flap loss and both wounds managed with dressing conservatively. From monitoring and follow up of the patients with head and neck reconstruction in our study, all flaps survived successfully with acceptable aesthetic result, color matching with adjacent tissue, no contour deformity. Same results were emphasized in previous studies for the head and neck reconstruction Behan<sup>5</sup> and Lim.<sup>14</sup> The use

of keystone flap in the lower limb to be an easy and more reliable option than other transposition and reverse flow and perforator flaps for small defects.<sup>2,15</sup> We applied keystone flap for lower extremity reconstruction similar to Aravind<sup>14</sup> study, closure of defects achieved with simple technique, without the need for microsurgical expertise and short operative duration. We noticed keystone flap can cover larger defects in trunk and thigh due to the laxity of skin where it can be stretched easily. In the leg it is good option for vertical defects oriented parallel to the limb in which flap mobilized medially and laterally. Flap coverage for defects around the ankle joint and heel area defects is more difficult and put extra tension on the flap due to limited tissue laxity in these areas, as one of the patients with heel reconstruction developed wound dehiscence. Defects of myelomeningocele in the lower back are difficult to close with primary repair due to the tension and may result in flap loss in the midline.<sup>16</sup> In our study; we used bilateral keystone flap for myelomeningocele defect closure, we incised the deep fascia to facilitate movement of the flap with the need for undermining of the flap (less than 50% of the flap) to allow closure without tension. Keystone flap provide a reliable solution for relatively large myelomeningocele defects with simple technique and

excellent blood supply depending on constant perforators from the underlying muscles.<sup>16</sup> We have used also keystone flap for myelomeningocele along with

bipedicle flap for large defects, keystone in one side and bipedicle flap in the other side to reach the midline and close the defect as shown in Figure (6).



**Figure (6).** **A:** Myelomeningocele defect preoperatively. **B:** immediately after closure. **C:** after one month.

Keystone flap is versatile and can be used in almost everywhere and its application in upper limb especially for the fingers is being practiced recently as it offers local, sensate and single stage flap.<sup>17</sup> We have

used Keystone for two patient's finger reconstruction both traumatic and Small wounds but amenable for direct closure, complete closure and healing were achieved in both Cases.

## Conclusions

Keystone flap is a reliable flap with excellent survival rate, versatile and can be used for skin defects in different regions of the body with low complication rate. Easy technique for learning by surgeons and

have short operative duration with good cosmetic outcome. Keystone flap use is recommended especially in areas with great tissue laxity.

## Conflicts of interest

The author reports no conflicts of interest.

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