Original Article

Electrical Burns

Utilization of Keystone Flaps in High Voltage Electrical Burns

Faisal Ashfaque[1], Hassan Kashif[2] and Nasreen Siddiqui[3]

ABSTRACT

Objective: This study aims to describe the use of Keystone flaps in patients with high voltage electrical injuries where local flaps were a possibility.

Study Design: Descriptive / analytic study.

Place and Duration of Study: This study was conducted at the Bolan Medical Complex Hospital and Jilani Hospital Quetta, Pakistan from April 2013 to August 2015

Materials and Methods: A total of ten patients with eleven high voltage electrical injury wounds reconstructed with keystone flaps were identified. Variables noted were patient demographics, comorbid conditions, size and location of defect, type of keystone flap used, and complications noted. SPSS 14 was used to note the variables. No statistical test applies to this study.

Results: Eleven defects in ten patients were reconstructed with Keystone flaps. Eight of the defects were on lower extremity, two on upper extremity and one on abdomen. The most commonly employed flap was Type IV keystone flap in six patients, Type II A in two patients, Type III in one and Type II B in one patient. No total flap failures were noted. One flap suffered distal one cm flap loss but after debridement, direct closure was obtained. Two patients had wound dehiscence requiring resuturing.

Conclusion: This case series demonstrated the safety, reliability and applicability of Keystone flaps in selected defects secondary to high voltage electrical injury.

Key Words: Keystone Flap, High voltage electrical burn, local flaps

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INTRODUCTION

High voltage electrical injury is a devastating injury as it affects not only the skin but also the muscle, nerves and vessels and thus is a major cause of morbidity and mortality[1]. Usually, it is work related injury in young individuals. It also happens as a result of negligence in third world countries, when common people try to gain illegal access to the cities' electrical grid work[2]. Electrical burns are either flash, flame or contact burns or their combination[3]. The severity of burn is dependent on source contact area entry and exit points. 80% of entry wounds occur in upper extremity while 70% of exit wounds occur in lower extremity. Amputation rates vary between 10% to 68% [4,5].

[1.] Department of Plastic Surgery, Jilani Hospital, Quetta.
[2.] Department of Plastic Surgery, Hamilton Health Sciences, Ontario, Canada.
[3.] Department of Plastic Surgery, Karachi Medical & Dental College and Abbasi Shaheed Hospital, Karachi.

Correspondence: Faisal Ashfaque, Fellow Plastic Surgery, Broomfield hospital, Essex, Chelmsford, UK. Institution: Jilani Hospital, Quetta.
Contact No: +447762083876
Email: faisalashfaque@hotmail.com

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To preserve important structures and function of limb, early debridement and coverage with vascularized tissue is rule [6,7].

Flap coverage is the best method as electrical injuries are full thickness burns and wounds need coverage of vital structures and exposed bone. As a rule, if local tissue is available, local flaps are preferred[8]. However, certain wounds like around the wrist are so large and extensively damaged that they demand distant or free tissue transfer as a coverage option[9,10].

Keystone perforator flaps were first described in 2003 by Behan[11] and has now been used in reconstruction of wounds from head to toe[12,13]. Their easy elevation requiring minimal training, short operative time, minimal postoperative care and like with like replacement characteristics have made them a useful tool in the armamentarium of are constructive surgeon. The purpose of this retrospective case series is to document its use and safety in selected defect secondary to high voltage electrical injuries. This is the first documented series in patients with high voltage electrical injuries.

MATERIALS AND METHODS

All case records of patients presenting with electrical injury and where keystone perforator flap was used as primary mode of reconstruction were reviewed using a data collection protocol. The patients were operated at Bolan medical complex hospital and Jilani hospital

Quetta, Pakistan from April 2013 to August 2015. Variables noted were patient demographics, comorbid conditions, size and location of defect, type of keystone flap used, and complications noted. SPSS 14 was used to note the variables. No statistical test applies to this study.

RESULTS

A total of ten patients with eleven high voltage electrical injury wounds reconstructed with keystone flaps were identified (Table 1). All of them were males. Average age was 15 to 45 years with mean of 26 years. Only one patient was smoker and had hypertension too. None of other patients had any comorbidities. All patients had other injuries as well and this was not the only procedure done in those patients. Most of the defects were on lower extremities (n=8), followed by upper extremity (n=2) and abdomen (n=1). In case of lower extremity, five defects were around knee, two on anterior middle part of leg and one on dorsum of foot. In upper extremity wounds, one wound was in axilla and one was a cubital fossa wound. The trunk wound was in the right lower quadrant. Type IV was the most common keystone flap used (n=6) followed by type II A (n=3), type III in one and type II B in one patient. All the knee defects were reconstructed by type IV flaps, anterior leg and axillary defects by type II, abdominal defect by type II and elbow defect by type III flaps. Complications were observed in 27% of patients. Partial flap necrosis was observed in one patient that was managed by skin grafting and wound dehiscence in two patients, which required secondary suturing. No total necrosis of flap was observed.

Case examples:

Case 1: (Patient # 2) is a 45 years old patient with High voltage electrical injury of right forearm leading to amputation and contact full thickness burn of right axilla. After debridement, Type II A flap designed and incised till the fascia. Deep fascia was also divided to get enough movement of the flap. Flap survived completely with good range of motion of shoulder joint afterwards.

Case 2: (Patient # 4) is a 28 years old patient with high voltage electrical injuries of scalp and two wounds on knee joint. Scalp wound was managed by scalp rotation flaps with skin grafting of donor site while larger wound (9.5cm x 8cm) around knee with exposed patella was covered by type IV keystone flap with proximal portion undermined. Knee was kept in splint for two and half weeks and sutures removed after three weeks. Knee joint had full range of motion, but sutures marks left ugly scarring.

Case 3: (Patient # 7) is 30 years old male with late presented contact full thickness burn secondary to high voltage electrical injury to his Right knee. Size of wound was 8 cm x 7.5 cm. Wound was marked as elliptical to design keystone flap and proximal portion of flap elevated. Donor site of flap was primarily closed.

Figure No.1: (Case 1: Patient # 2; Pre op, Per op and one month post op)

Figure No.2: (Case 2: Patient # 4; Pre op, per op, one month post op)

Figure No.3: (Case 3: Patient # 7; Pre Op and Post Op)

Case 4: (Patient # 9) is 24 years old male with high voltage contact burn resulting in (7 cm x 5 cm) wound on tibia and a small wound proximally. Although wound could be skin grafted we designed a keystone flap and incised a type II-A flap dividing the fascia and were able to close the donor site. Flap on third day showing complete survival.

Case 5: (Patient # 10) is a 6 cm x 4 cm wound on dorsum of foot. Type IV flap elevated but we were unable to approximate donor site primarily, so it was skin grafted. Distal portion underwent necrosis that was managed by debridement and primary closure.

Figure No.4: (Case 4: Patient # 9; Pre Op, Per Op and Post Op)

Figure No.5: (Case: 5: Patient # 10; Pre op, Per op and one month post op)

Table No.1: Electrical injury wounds reconstructed with keystone flaps in patients

Patient #	Age	Gender	Defect			Type of flap used	Complications		
			Location	Nature	Size in cm		Total flap loss	Partial flap loss	others
1A	28	Male	Right middle leg	Tibia visible	7*3.5	2A	None	None	
1B	28	Male	Right lower abdomen	Full thickness	5.5*5	2B	None	None	Wound dehiscence
2	45	Male	Right axilla	Full thickness	7*3.5	2A	None	None	
3	21	Male	Left knee	Patella visible	7*5	4	None	None	
4	21	Male	Left knee	Patella visible	8*8.5	4	None	None	Poor scarring
5	15	Male	Left elbow	Full thickness	8*5.5	3	None	None	
6	20	Male	Left distal thigh	Full thickness	7.5*5	4 with skin graft	None	None	
7	24	Male	Right knee	Full thickness	6*5	4	None	None	
8	27	Male	Right knee	Exposed knee	15*9	4 with skin graft	None	None	Delayed healing
9	25	Male	Left distal leg	Tibia visible	6*3.5	2A	None	None	
10	30	Male	Right dorsum of foot	Visible tendon	5*3.5	4 with skin graft	None	Distal one cm	

DISCUSSION

It is obvious from our study that keystone flap is useful for selected wounds that have resulted from high voltage electrical injury. Although keystone flap usage in full thickness burns has been reported[14] but this is first case series documenting its usage in high voltage electrical burns. High voltage electrical burns are usually full thickness burns mainly around joints with a high amputation rate. When extremity is salvageable, these wounds require complex reconstructions, so keystone flap is useful only when local tissue is

available. It is useful only for small exit wounds in lower extremity or around the joints. Smaller defects on legs can be reconstructed by type I or II flaps[15,16] but knee defects are difficult to approximate by type I or II flaps[17]. Type IV flaps are best suited for this purpose, but their design is technically demanding and require a bit of thought process[15]. Whenever possible, proximal portion of flap should be elevated as distal portion is known to be supplied by perforators from around the knee anastomosis. It is essential to keep the leg extended by a splint as there is significant tension during closure. We have also found use of horizontal mattress sutures better for skin closure as advocated by Behan[17] than skin staples, but they leave ugly suture marks when removed after three weeks. We have used type IV keystone flap for very large defect around knee but with skin grafting of donor site. These wounds would have otherwise required bilateral gastrocnemius flaps or free flaps. However, it has the obvious advantage of not sacrificing a functional muscle for knee coverage, shorter operative time and less technicality when compared to a free flap.

When reconstructing leg defects, keystone flaps are superior to bipedicle flaps because of its vascularity[18], possibility of future usage, variability of usage as different types[16]. However, it is not useful for large defects and its arc of rotation is limited[19]. These two limitations must be kept in mind before embarking in usage of this flap. Perforator flaps are another option in leg defects, but they are tedious, technically demanding, and more time consuming when compared to keystone flaps[13]. We have observed as mentioned in literature[13] the designing and planning more difficult and artistic than elevation of flap that is straight forward and most complication arise because of the poor designing.

Partial flap necrosis was seen when type IV flap was attempted to cover dorsum of ankle defect with flap from dorsum of foot. We were not able to close the donor site primarily and skin grafted it. However, after debridement, wound approximation could be achieved. This shows that keystone flaps are not a good option for reconstruction of medium sized defects of anterior ankle and distant flap like distally based sural flap may be a better option for these defects.

As most of our patients were young and all of them were Asians, no effect of skin type on vascularity of flap was observed. This has also been documented previously[13]. However, age and location of defect were the two precluding factors in getting the skin laxity required for usage of type I or type II flaps. It this is not achievable; Type III or Type IV flaps will be needed.

We elevated initial flaps as mentioned by Behan using blunt dissection to preserve lateral vessels and nerves entering flap, however later, we used diathermy to dissect down to fascia sacrificing these vessels and found no detrimental effect on vascularity of flap. This has been observed by others as well[12]. We have not used drains in any of our patients and think if hemostasis is secured intraoperatively, no drains are necessary.

This is a retrospective, small case series documenting reconstruction of high voltage contact burns with keystone flaps. We know these limitations and purpose of presenting this is to show that keystone flap is a possibility in high voltage burns in selected patients. This should be interpreted in this context.

CONCLUSION

This case series documents the use of keystone flaps in full thickness wounds of high voltage electrical injury in selected patients. It is the availability of local tissue that allows usage of this flap while location and laxity of tissues determine the type of flap used for coverage. This study confirms that keystone is highly versatile and technically straight forward reconstructive option for wounds from head to toe.

Author's Contribution:

Concept & Design of Study:	Faisal Ashfaque
Drafting:	Hassan Kashif
Data Analysis:	Nasreen Siddiqui
Revisiting Critically:	Faisal Ashfaque, Hassan Kashif
Final Approval of version:	Faisal Ashfaque

Conflict of Interest: The study has no conflict of interest to declare by any author.

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