Original Article

Keystone flaps in coloured skin: Flap technology for the masses?

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ABSTRACT

Introduction: Viscoelastic properties of skin in coloured ethnic groups are less favourable compared to Caucasians for executing Keystone flaps. Keystone flaps have so far been evaluated and reported only in Caucasians. The potential of Keystone flaps in a coloured ethnic group is yet unknown. **Aim:** This article reviews the experience to reconstruct skin defects presenting in a coloured ethnic group, by using Keystone flaps, with a review of existing literature. **Design:** Uncontrolled case series. **Materials and Methods:** This retrospective review involves 55 consecutive Keystone flaps used from 2009 to 2012, for skin defects in various locations. Patient demographic data, medical history, co-morbidity, surgical indication, defect features, complications, and clinical outcomes are evaluated and presented. **Results:** In this population group with Fitzpatrick type 4 and 5 skin, the average patient age was 35.73. Though 60% of flaps (33/55) in the series involved specific risk factors, only two flaps failed. Though seven flaps had complications, sound healing was achieved by suitable intervention giving a success rate of 96.36%. Skin grafts were needed in only four cases. **Conclusions:** Keystone flaps achieve primary wound healing for a wide spectrum of defects with an acceptable success rate in a coloured skin population with unfavorable biophysical properties. By avoiding conventional local flaps and at times even microsurgical flaps, good aesthetic outcome is achieved without additional skin grafts or extensive operative time. All advantages seen in previous studies were verified. These benefits can be most appreciated in coloured populations, with limited resources and higher proportion of younger patients and unfavorable defects.

KEY WORDS

Skin ethnic variations; flap success rate; flap learning curve; flap resources; Keystone flap; skin extensibility

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INTRODUCTION

The Keystone design perforator islanded flap (KDPIF) was first published in 2003.[1] The flap consists of two conjoint V-Y island flaps and is being increasingly used, thanks to its simplicity, safety, and superior cosmesis. However, an essential requirement for this flap is favorable viscoelastic properties of the flap and surrounding tissue.[2,3]

Past experience with the Keystone flap, as seen in the

literature, has mainly been with elderly patients in a white/Caucasian population [Table 1],[1-8] where the biophysical properties of skin are favorable for the flap. Given that differences in skin function across races are most marked in the biomechanical parameters,[9,10] validity of this flap in coloured skin with unfavorable properties, as in an Asian population, is very relevant.

This paper presents our experience with Keystone flaps in a population that has coloured skin – Fitzpatrick type IV and V. This retrospective study aims to determine the feasibility and safety of the Keystone flap in coloured skin – possible applications with regard to defect aetiology and region, younger patient age, technical difficulty in the learning curve, and benefits of the flap compared to conventional techniques. We have also suggested potential risk factors and their impact on the outcome.

MATERIALS AND METHODS

From February 2009 to July 2012, 41 patients were operated upon for skin defects in various locations. Patient demographic data, medical history, comorbidity, potential risk factors, surgical indication, defect features, complications, outcome, and follow up care were evaluated and presented as an uncontrolled case series.

Flap planning and design

After excision, the defect is considered as an ellipse for flap planning [Figure 1a]. The ellipse should lie with its axis parallel to the line of cutaneous nerves, veins and/or known cutaneous perforators. The flap is designed within dermatomal patterns, and straddles these longitudinal running structures, which are incorporated in the flap and preserved during soft tissue dissection. The side of the defect with greater tissue laxity is chosen as flap donor area. If a single flap seems inadequate, another flap from opposite side of the ellipse is marked and kept ready.

An incision at 90 degrees at either end of the defect meets the curvilinear line of the flap markout. The width of the flap equals the width of the defect [Figure 1b]. This curvature or Keystone shape is then mobilized. Flap length is governed by the length of the elliptical excision.

Elevation and defect closure: Surgical technique

Incisions are taken with an extensible approach – cut as you go – to mobilize a suitable flap. The skin incision is deepened toward the fascia by blunt dissection. This preserves the visible linear structures including superficial veins and nerves [Figure 9e], and also few lymphatics. The first step [Figure 1c] in wound closure involves closing the 'V' in the flap defect as a 'Y'. This creates tissue laxity in the center of the flap at right angles to the 'Y' and also narrows the secondary defect. The flap is then sutured into the original defect and donor area closed using standard techniques[1,8] [Figure 1d]. A drain is placed beneath the flap when the defect needs it – as with a pressure sore excision or lymph node dissection.

In addition to the standard flap types mentioned initially by Behan[1] [Figure 1], subsequent publications have mentioned modifications.[3,11] We have devised a new modification (Type E) to the types described

Table 1: Previous papers in literature on Keystone flaps

Reference number, year	Author	Skin type in the patient group	Average patient age	Number of cases in series	Defect aetiology	Region of study population
1, 2003	Felix C. Behan	Not mentioned, possibly white	Not mentioned, possibly for more than 50 years	300	Not mentioned, possibly skin cancer, few trauma	Australia
2, 2003	IT Jackson	Commentary on article in reference 1				
4, 2006	Felix C Behan	Not specified, possibly white	74 years	9	Recurrent cancer post radiation	Australia
5, 2007	Philippe Pelissier	Not mentioned, possibly white	52 years	12	Cancer, few trauma	France and Australia
6, 2008	Moncrieff	Not mentioned, possibly white	Not mentioned, Possibly elderly	176	Melanoma	Australia
3, 2010	Marc D. Moncrieff	Not mentioned, possibly white	Not mentioned, possibly elderly	Not mentioned	Not mentioned, possibly Carcinoma	Australia
7, 2010	Felix Behan	Not mentioned, possibly white	80 years	8 cases	Advanced cancer	Australia
8, 2011	Khouri *et al*.	Not mentioned	Not mentioned	28 cases	Cancer and trauma	USA

already – most useful in the distal leg – and compiled the various modifications of the Keystone flap as modified type A-E [Table 2 and Figure 2].

Of all these types of Keystone flaps, a Skin graft is needed only in the Type IIB and IV flaps.

RESULTS AND OBSERVATIONS

This study involved 41 cases with 42 defects involving 55 flaps. The average age (range 6-75 years) of the patients was 35.73 years, most being male patients in the working age group. Defects were either traumatic (11/41), following elective excisions (14/41), or excision of inflammatory wounds (11/41). The rest (5/41) were defects due to surgical wound breakdown. More than two-third of the defects we encountered (28/41) involved the lower limb [Figure 3].

Of the 15 defects in the leg, 8 needed double flaps. Type IIA was the commonest flap type, done on 29 of the 55 occasions [Table 3]. The largest flap in this study was 32×20 cm, done on the lateral and posterior chest wall, the smallest flap was 14×7 mm on the digit.

The new modified type E flap that has evolved in our experience has been used on eight occasions. Of these, it was used as a double flap for three defects.

Thirty-three cases had a distinct risk factor while using the flap, with 31 of these being local factors such as harvesting flap from a zone of injury of a traumatic defect or from a zone of induration around an inflammatory defect. Despite the high prevalence of risk factors in our series, failure of the flap to achieve the reconstructive goal was seen in just two cases, giving an overall success rate of 96.36%. Both these cases had a local risk factor. There were seven other cases with complications, none of which resulted in a failure of reconstruction, of which five had an additional risk factor. Further, 26 cases healed smoothly without any problem in spite of a risk factor. Complications involving cases without any risk factors occurred in only two of the remaining 22 patients, both of which settled with minimal intervention [Table 4].

DISCUSSION

The variation in skin extensibility across different ethnic groups is due to the differential protection by melanin from UV rays.[9] With Asians forming more than half the population of our planet,[10] we attempt to validate this reconstructive technique in the background of potentially unfavorable factors encountered in a coloured ethnic group.

Table 2: Keystone flap types and their description

Standard flap type	Description	Modified flap type	Description
I	Skin incision only	A.	Intact skin on convex side of flap, but with fasciotomy
IIA	Division of deep fascia	B.	1 + 'V' skin incisions short of the defect
IIB	With split skin graft to secondary defect	C.	Single 'V' incision with fasciotomy on convex side of the flap
III	Double keystone flap	D.	Preservation of triangular skin area between defect and concave flap border
IV	Rotational Keystone flap	E.	Type IIA flap, but V incision avoided on side with deficient skin

Classic type I–IV flaps – Felix Behan[1] Modified flaps type 1–3 – Moncrieff *et al.*[3] Modified flap type 4 – Rao *et al.*[11] Modified flap type 5 – this article, our publication

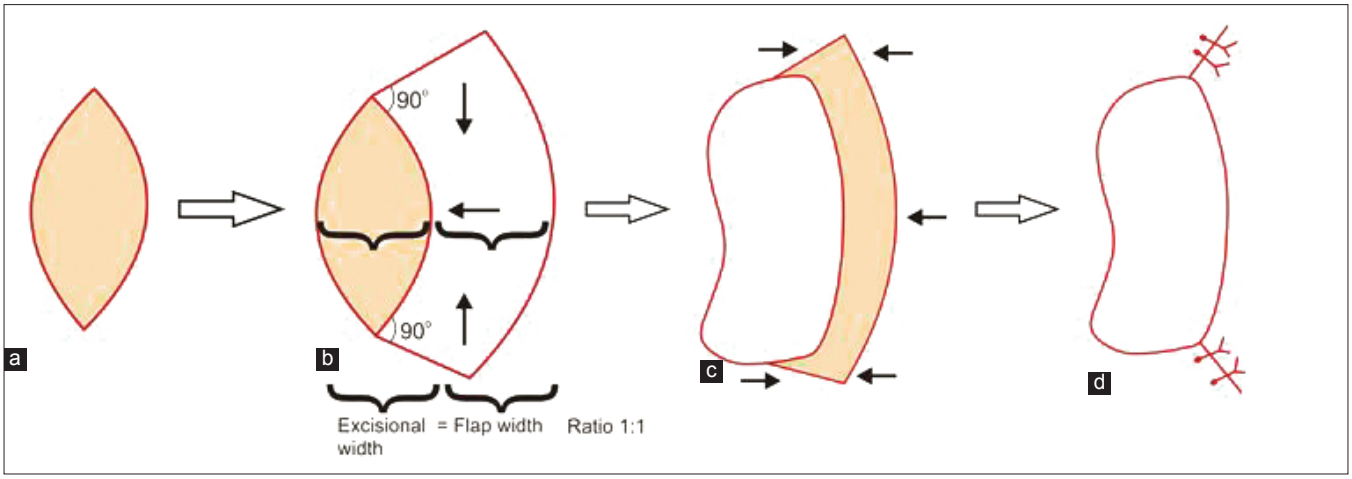

Figure 1: Diagram of classic type I

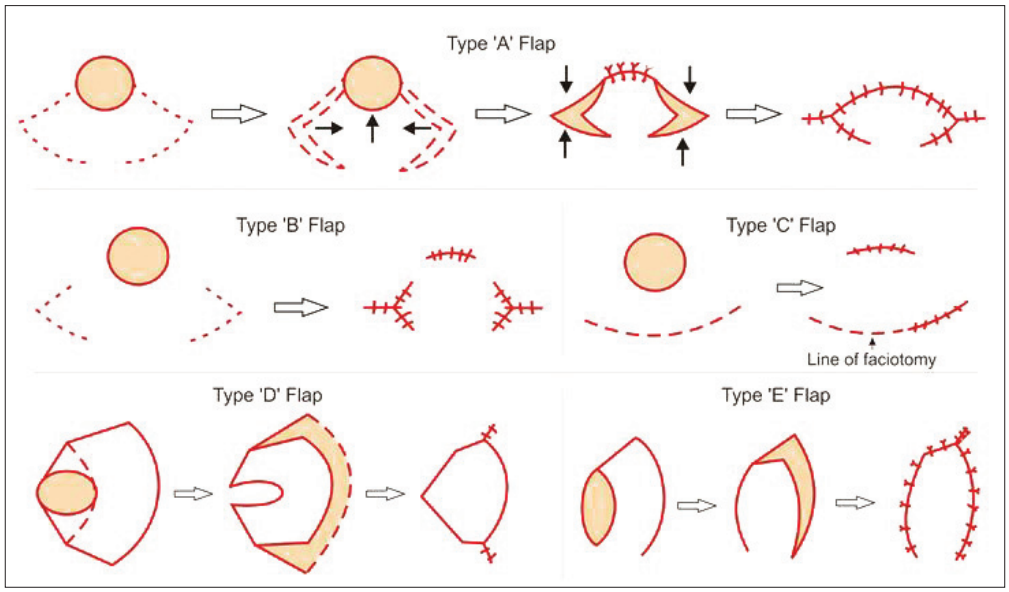

Figure 2: Diagram of modified type A-D and type E flap

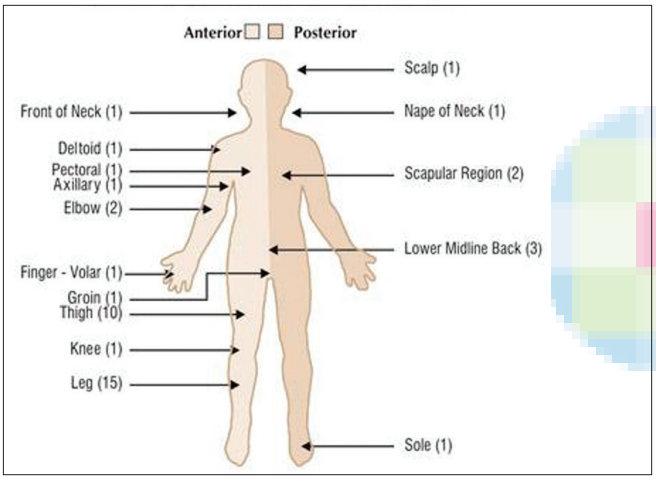

Figure 3: Region wise distribution of flaps

Table 3: Flap type and number: Single and double flaps

Standard flap type	Number of flaps	Modified flap type	Number of flaps	Flaps in defects needing dissimilar double flap	Gross total
I	3	A	2	6	55 flaps
IIA	29	B	Nil		
IIB	1	C	1		
III	Nil	D	5		
IV	1	E	8		
Total flaps	33		16		

Grand total number: cases-41, defects-42, flaps-55 Three cases of double Keystone flap involved use of two dissimilar flap types within the pair, a modified type A and type E in each double flap. Numbers under flap Type III (double/paired flap with both flaps of same type) have been included under the respective flap in the pair. Hence flap numbers for Type III is seen as Nil

Table 4: Risk factor and flap outcomes (complications, failure)

	NIL risk factors	Risk factor present
Smooth healing	20	26
Unfavorable outcome		
Complication	2	5
Failure	Nil	2
Both	2	7
Total	20+2=22	26+7=33

The vascular safety of the KDPIF is beyond all doubt; our experience merely supports this fact. However, at the cost of repetition, I quote Felix Behan – 'to design a flap the same width as the primary defect, immediately adjacent to it, that has essentially the same mobility characters and to expect it to not only close the original defect as well as its own large secondary defect seems empirically daring'. It is the design of this flap that apparently allows the rules of length and breadth ratio to be overruled, by optimum use of biophysical properties of skin.

Since modern literature demands classification and nomenclature, we have compiled the modifications of the KDPIF, in the chronological order of appearance in literature, and added to it our own modification as type E modified flap [Table 2].

The V-Y advancement at each end of the longitudinal axis of the flap creates a redundancy that can be used to further move the central tissue in a horizontal axis. The V-Y closure also narrows down the entire defect complex, including the secondary defect, reducing the net horizontal movement that the flap has to undergo.[1] Any Keystone flap design, including the modified type E

Figure 4: Chest wall defect, covered with a 30 × 20 cm flap. Intraoperative views of a 58 year lady with breast Cancer, invading into the pectoral muscles. (a) Ulcerative lesion after anterior chemotherapy. (b) 15 × 20 cm defect with ribs exposed. (c) 25 × 30 cm KDPI Flap incised. (d) and (e) Flap moves as a modified type D flap into defect and all wounds closed. (f) and (g) post operative views of flap at 10 weeks, after six cycles of radiotherapy

Figure 5: Axillary defect, covered with a 22 × 10 cm flap, also shows complication of wound gape. Intraoperative views of a 23-year-old lady with axillary Hidradenitis Suppurativa. (a) Presenting lesion after initial failed skin graft. (b) 13 × 10 cm defect. (c) and (d) 22 × 12 cm KDPI Flap incised for transfer as a type II A flap into defect. (e) Wound gape on posterior edge of wound. (f) and (g) Transfer and all wounds healing well at 12 weeks

flap is unique because this V-Y (Keystone) flap lies parallel to the defect [Figure 2]. A conventional V-Y flap is oriented perpendicular to the defect.[6]

Of our 55 flaps, the most favorable outcome is evident in cases with elective excisions and flaps from virgin tissue, without any risk factors whatsoever. Our biggest flaps were performed in such favorable conditions, a Mod type D flap for a chest wall defect and a type IIA flap for an axillary defect. Case 14 involved a 20 × 15 cm defect on the anterior chest wall following excision of a Breast Carcinoma involving the pectoral muscles [Figure 4]. A 30 × 20 cm flap was designed adjacent to the defect on the lateral and posterior chest wall. The flap was mobilized as a modified type 4 Keystone flap to cover the defect, needing a total operative time of 130 min. Any alternative flap would have needed about double the operative time, with additional morbidity due to the donor area and possible skin grafts. Case 30 involved a 13 × 10 axillary defect following excision for Hidradenitis

Figure 6: Case 32, thigh degloving injury, failure of reconstruction. (a) Run over injury R thigh, with necrosed skin on day 4. (b) Excision of devitalized tissue. (c) Closure by advancement of edge. (d) Breakdown of closure due to further fat and skin necrosis, condition at 4 weeks. (e) Closure using single type IIA flap. (f) Partial flap necrosis with debridement and resulting raw area. (g) Final healing at 10 weeks, after skin graft procedure

Figure 7: Complication major – partial flap necrosis, Case 7. Intraoperative views of a 35 year lady with run over injury to R leg with (a) Soft tissue defect of 8 × 15 cm. (b) 10 × 22 cm Type II A flap from medial side. (c) 11 × 20 cm modified type E Flap from lateral side used to close the defect. (d) Major complication – necrosis of peroneal flap. (e) and (f) Medial and lateral views at 8-month follow up

Suppurativa [Figure 5]. A 22 × 12 cm flap was designed immediately posterior to the defect and mobilized as a Type II A flap to achieve primary closure. In both the cases, patient and shoulder joint could be mobilized in 48 hours and further pain-free recovery was seen.

Only two flaps (case 15 and 32) failed to achieve their planned reconstructive goal. Case 15 involved a plantar flap of 3 × 1.5 cm done to cover a callous post-traumatic plantar ulcer. Parts of the flap had indurated tissue and the flap failed to move adequately in spite of division of the plantar fascia. The closure led to a wound breakdown that finally healed by secondary intension. Case 32 involved a 30 × 15 cm flap done for a thigh degloving injury with raw areas. The critical part of the flap underwent delayed necrosis; defect was eventually covered by a skin graft [Figure 6].

Thus, both the flaps that failed to achieve the reconstructive goal involved a risk factor. None of the flaps without additional risk factors faced a failure. Consequently, the overall success rate of 96.36% achieved is comparable to any other similar reconstructive technique. This is also comparable to the success rate for the same reconstructive technique in other previous reports in literature, even.though these reports indicate a lower proportion of unfavourable defects. Felix Behan reported a success of 99.6% in his 300 cases, Moncrieff *et al.*[8] had a 99.4% success rate over 176 cases and Khouri *et al.*[6] reported a 97% success rate over 28 flaps.

Of the successful 53 flaps, risk factors were present in 31 flaps, of which five had some complication. Case 7 was the only complication that needed a major intervention. It involved a run over injury to the leg with exposed tibia over 8 × 15 cm in the central part of the leg [Figure 7]. This was initially covered with two modified type E flaps from each side of the leg defect. The medial 10 × 22 cm flap healed reasonably, but the proximal suture line of the peroneal 16 × 8 cm flap had a wound gape due to ischaemic necrosis

Figure 8: Complication minor - wound breakdown, Case 13. Intraoperative views of a 17 year boy with avulsion injury. (a) Soft tissue defect of 6 × 7 cm on upper arm, with medial flap marked. (b) and (c) Medial and lateral modified type D flaps, after transfer in the initial postoperative phase. (d) Wound gape at 1 week. (e) and (f) Well settled wounds at 12 weeks post-op

of the adjacent flap and leg tissue. After debridement and transposition of the remaining part of the peroneal flap, the wound healed smoothly. A skin graft used to cover the donor defect after transposition healed smoothly.

All other four cases with complications related to local risk factors settled with minor intervention. Case 13 involved a wound breakdown that settled with resuturing [Figure 8]. The traumatic defect on the deltoid made the extensibility of the flap donor area less favourable due to an inherently high resting skin tension and proximity of the zone of injury.

Only two of the 22 defects without any local risk factors encountered any complications – both were minor in nature, which settled without any major intervention. Case 30 [Figure 5] involved a single Type II A flap done from the parascapular region for an axillary defect following excision for hidradenitis suppurativa. The breakdown of the posterior edge of the flap could have been avoided by using an additional anterior flap, to decrease the movement of the posterior flap. It is our suggestion that two flaps be used without hesitation to avoid delay in wound healing and additional procedures. However, in this lady, the additional anterior flap from the lateral pectoral region was not considered to prevent any breast deformity. Case 35 involved a double flap done for closure of a 25 × 13 cm ALT flap from the middle and lower thirds of the thigh. The lateral flap closure line in the region of the TFL gaped along the posterior edge. Thus, we suggest cautious use of the KDPIF for defects in the lower thirds of the thigh, unlike the rest of the thigh.

Though seven flaps involving some risk factor developed problems, 26 flaps were successful and healed smoothly in spite of a risk factor – a scenario where other perforator or fasciocutaneous flaps would be more cautiously used. Thus, the reconstructive technique has achieved a favorable outcome, as seen from the failure and complication rates, in cases both with and without risk factors.

These findings make us provisionally agree with the original author that islanding a piece of skin does enhance its blood supply – an Island is safer than a peninsula.[12] This is probably the basis of the additional safety provided by the flap in the presence of local or general risk factors. Thus, we recommend use of this technique, when a flap is needed, in the background of local problems such as a wide zone of induration (post inflammation), significant zone of injury (post-traumatic oedema), diabetic or hypertensive vasculapathy, vascular problems such as varicose veins or systemic problems such as renal or hepatic disease. Case 20 involved an open fracture of middle third of the leg with a soft tissue defect of 7 × 4 cm. In spite of a wide zone of injury, the defect was closed with two Type II A flaps, one from either side (thus a type III flap) and sound

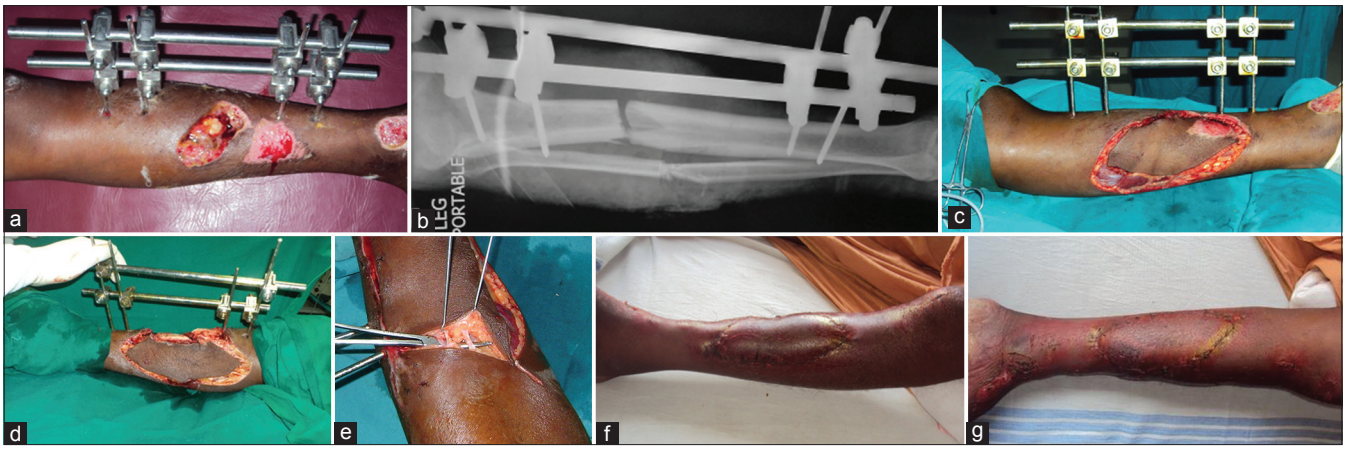

Figure 9: Case no. 42, flap with local risk factors and smooth healing) double flap for M 1/3 leg defect. Intraoperative views of a 28yr lady with RTA. (a) Open fracture Leg. (b) R leg – X-ray. (c) and (d) Medial and lateral flaps of 8 × 12 cm size incised. (e) Technique of preserving superficial vein and nerve while dividing deep fascia. (f) and (g) Well settled flaps at 6 weeks after transfer as type II A flap

Figure 10: Case 18, flap used to treat wound gape with underlying leg ischaemia. Sixty-nine year lady with CABG presenting with (a) breakdown of leg wound following harvesting a vein graft. (b) Defect after debridement. (c) Closure with type II A flap

healing was achieved. The sensate cover achieved had a good aesthetic outcome as well [Figure 9].

In such scenarios, it is only the original author who has made suggestions about the use of this flap for traumatic defects,[1] that of using the Type IV flap, which involves a skin graft. We have on the contrary, achieved successful healing for most traumatic leg defects including those with open fractures, without use of skin grafts. This was achieved by use of double flaps when a single was felt inadequate and by use of the Modified Type E variant. Only 2 of 15 leg defects needed a skin graft (along with a flap) to achieve wound healing, one of which was following partial flap necrosis. Thus, judicious planning can achieve a good aesthetic reconstruction using KDPIF for open fractures as well. Nevertheless, with traumatic defects, guarded use of this reconstructive technique is suggested. Both the cases in this series that lead to a reconstruction failure involved post-traumatic defects. However, as recommended with Keystone flaps for radiation defects,[4] in the presence of any risk factor as mentioned earlier, it may be prudent to graft the flap donor defect to reduce overall tension. This will decrease the risk of wound breakdown and further intervention.

Another useful application of this technique, on similar grounds, is for post-operative wound breakdowns. High tension in wound approximation and possible ischaemia of wound edges usually lead to the initial breakdown. By addressing both these issues directly, the Keystone flap can be a very potent tool to tackle this problem. Case 18 involved a 65-year-old lady with DM, HTN, and IHD. She developed a breakdown of the upper leg wound following a vein graft harvested for CABG. The wound edges were friable, edematous, and resulted in a 10×4 cm defect after debridement. This was closed with a single 13×6 cm Type 2A KDIPFlap from the adjacent calf. The wound went on to heal smoothly [Figure 10].

In fact, if this possibility of a wound breakdown, or difficulty in primary closure, is anticipated when the wound presents initially, the KDPIF provides a means to redistribute the wound tension over a wider area to ensure smooth healing. Of the 14 cases in this series where this scenario presented to us, the most common indication was the donor area of the ALT (anterolateral thigh) flap. Case 15 involved a 15×10 cm ALT flap done for a heel defect. After direct closure of the donor defect, there was an area of 7×10 cm that could not be

Figure 11: Primary closure of ALT flap donor area using type IIA Keystone flap. Intraoperative views of a 55 year male presenting with avulsion injury R heel. (a) Free ALT flap harvested and awaiting inset. (b) Flap donor area closed primarily to the maximum, residual defect of 7 × 10 cm. (c) 8 × 18 cm flap incised on medial side. (d) Flap transferred as a Type II A flap after V–Y advancement. (e) Complete closure of flap and donor area. (f) Sound healing at 12 weeks post-op. (g) Contrast scenario – high tension with edge necrosis after direct closure of ALT donor area

approximated directly. This was closed using a Type II A KDPIF to achieve a smooth, pain-free wound healing and early mobilization [Figure 11].

All cases in this series were done in a population with common background factors, on account of coloured skin and a less favorable demographic profile that increased the baseline risk for this flap. Many patients had an additional local risk factor as well. All of our cases involved Fitzpatrick Skin Type 4 and 5, where the skin extensibility and biophysical properties are less favorable compared to Caucasian Skin.[9,10] None of the previous authors [Table 1] have mentioned about any cases involving unfavorable skin types. Also, most patients in our experience were in a younger age group, with an average age of 35.73 years; here too the skin extensibility is less favorable for this technique compared to an older population group as seen with previous cases series mentioned in the literature. The favorable success and complication rates seen in this series [Table 4] suggest that neither skin type nor patient age are per say a deterrent for use of this flap. In contrast, local risk factors adversely affect tissue extensibility and lead to a higher complication rate compared to cases without local risk factors. Apart from one publication,[7] most other cases involved flaps without any mention of local risk factors. Nevertheless, if the tissue extensibility can be judged reasonably to account for any loss due to local risk factors, the flap vascularity and residual extensibility are adequate for the flap to be safely used.

Thus, Keystone flaps achieve primary wound healing for a wide spectrum of defects with minimal pain, a sensate cover and good aesthesis. The technique possibly can obviate the need for microsurgical procedures, additional skin grafts, and extensive operative time, though this has not been objectively documented in the study. As a more physiological procedure, the hospitalization time,

recovery, mobilization and rehabilitation periods, and return to work are favorable to the patient. This outcome, by being consistently reproducible, converts into a good overall success rate.

All cases in this series were safely done by a single surgeon with about 5-year experience post qualification, outside an institutional set up, without any first-hand experience of this flap. However, the author's previous experience with perforator topography, distribution, and dissection [13] did add to the comfort level while dissecting and transferring these flaps. But, in no case was it necessary to either preoperatively identify any perforator vessel supplying the flap or attempt to visualize it during dissection. Thus, preoperative imaging by Doppler or any other modality was not needed at all, simplifying matters further. All the cases with complications or failures involved errors in planning the flap, not in flap execution. Simpler operative technique usually converts into lesser operative time for the procedure, especially compared to alternative options of pedicled or free flap transfers. All these issues collectively convince us that the KDPIF does indeed have a shorter learning curve.

This is in contrast to other newer reconstructive techniques like perforator-based free flaps that provide alternative options with lesser donor morbidity; but the steep technical learning curve and the long operative times have been barriers to their widespread use.[8]

These indirect benefits, combined with its inherent direct benefits, give the technique a unique potential for wide application by making the best use of available resources – human, material, monetary, and time. Favorable use of theater time, material, and manpower convert into immense benefits for the health care system. In this background, an overall success rate of 96.36% seen in this case series has an additional significance. Given that health care resources are usually inadequate in coloured population groups,

Figure 12: Case 37 bilateral elbow PBC corrected in single stage. Intraoperative views of a 32 year lady with bilateral elbow postburn contracture. Upper row (a-e); L side, Lower row (f-j), R side. (a) & (f) Initial deformity, (b) & (g) After defect creation and flap incisions, (c) & (h) After flap transfer into defect, (d) & (i) and (e) & (j) Postoperative views – in full flexion and extension

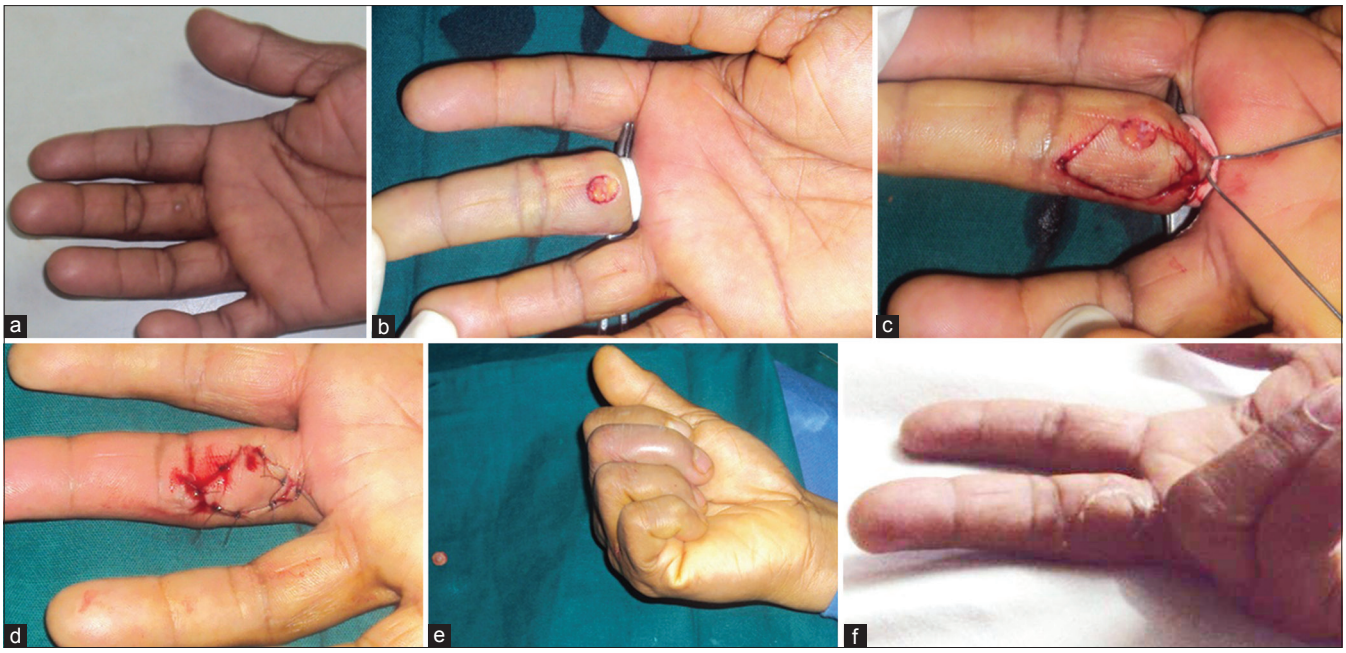

Figure 13: Case 12, volar digital defect and flap. Fifty-eight year old lady with benign palmar skin nodule. (a) On presentation. (b) 5 × 6 mm defect after excision. (c) 14 × 7 mm type I flap incised. (d) Transferred and inset. (e) and (f) Full ROM maintained in postoperative period

Figure 14: Case 28, unstable scar on the Tendo Achilles (a) Initial lesion (b, c & d); Defect created, lateral & medial flaps incised; (e & f) - flaps mobilised to move into defect and sutured in final place; (g & h) final outcome 8 months later with full ankle range of motion

with a demographic cluster in the younger age, the safety and cost benefits offered by this reconstructive technique make it a good option to tackle skin defects in such a population group.

These 'resource friendly' features of the flap are illustrated in Case 37 [Figure 12] that involved a post burn elbow flexion contracture on both the limbs in a 32-year lady. Conventional skin grafts with or without a local flap would involve significant scarring, post op immobilization, physiotherapy, graft pressure therapy, etc., Thus, the second limb would be operated only after adequate postoperative functional recovery of the first limb. The KDPIF technique permitted correction of both the sides in a single setting, needing a total tourniquet time of 75 min, avoiding all skin grafts. The minimal postoperative discomfort allowed her to use both the limbs for personal work by 48 h itself. Thus, the recovery period was significantly shorter than after conventional correction.

As this flap is more widely used, its specific limitations or benefits in particular regions can be evaluated more objectively. For example, the smallest flap in our series involved a 4×6 mm defect on the volar proximal phalanx of the dominant hand middle finger of a 65-year-old lady, due to excision of an enlarging skin nodule [Figure 13]. Though tension following direct closure could have permitted wound healing, functional rehabilitation would have been delayed. By use of a 14×7 mm flap to further

decrease the tension of wound closure, smooth pain free early mobilization, and return to work could be achieved.

On the other hand, plantar skin may increase risk for flap use, as seen in our series. In our case, this inextensible glabrous plantar skin had some induration as an additional risk factor. Though previous authors have reported successful flaps on the sole, [1,5] technical details specific to this region have not been mentioned. We recommend caution in use of this technique in the lower third of the thigh and the deltoid regions. As mentioned already, we got away with minor intervention when faced with minor complication in the form of a wound breakdown in these regions.

For flaps planned in the lower third of the leg, involving defects in the lower or middle third region, the conventional design of the KDPIF is not possible. This is due to an inherent transverse deficiency of soft tissue in the lower third of the leg that makes it difficult to use a V-Y maneuver at the distal end (toward ankle) of a flap planned along the long axis of the leg. It is in this scenario that our Type E modification of the KDPIF offers a higher margin of safety, by limiting the V-Y maneuver to the upper end of the flap [Figure 2], either as a single (Case 3) or double [Figure 14 , Case 28] flap. By avoiding a V-Y maneuver distally, tissue for the flap is recruited only from the area of laxity, the proximal leg.

Though the 'additional scars' due to long incisions increase the chances of problems due to any scar hypertrophy or keloidal changes, especially while dealing with Type 4 and 5 skin, we did not encounter this in our short experience over 43 months.

As experience with the KDPIF progressed, we found ourselves doing flaps for defects that we would have previously grafted. The flap is thus versatile, catering to a variety of situations involving various locations, defect types and surgeons and setups with a wide range of resources.

To conclude, this technique can be particularly useful to plastic surgeons working alone, who have a limited comfort zone and safety margin, when practicing their art and skill. At the same time, the technique can vastly enhance the freedom available to the Surgeon, to use his creativity while at work – to achieve the best of reconstruction for the patient and best of simplicity and aesthesis to the satisfaction of the surgeon.

We firmly believe, this technique can have far reaching benefits – and is meant for the vast multitude of surgeons and needy patients, thus becoming a technology for the masses!

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