*Original article*

# Keystone design perforator island flap: our experience for coverage of lower limb defects

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**Abstract:**

The fusion of concept of perforasome and trapezoid design made Keystone design Perforator Island flap (KDPIF). This flap was first introduced by Behan in 2003 and since then many modifications were done. Keeping the principles of KDPIF, two modifications were done in this study. ***Aims:*** to determine reliability and advantages of KDPIF for lower limb defect coverage. ***Materials and Methods:***15 cases were done in Plastic surgery department of Rajshahi Medical College Hospital from October 2020 to September 2022. ***Results:*** The largest wound measuring 11X 10 $cm^2$ on thigh defect following wide local excision of sarcoma was covered by the largest dimension flap measuring 16X 11 $cm^2$. In most of the cases (7 cases), Type IIA KDPIF was done. With co-morbidities, 14 flaps survived without any complications. Range operating time was 35-110 minutes. ***Conclusion:*** Due to its reliable vascularity and easy execution and good outcomes, KDPIF is one of the best choices for lower limb defect coverage.

**Keywords:** Lower limb defect; exposed bone; KDPIF.

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## Introduction:

The keystone design island flap (KDPIF), a curvilinear-shaped trapezoidal designed two V-Y advancrment flaps was first introduced by Behan in 2003[1]. Behan[1] recommends designing the flap within angiosome teritory including superficial and cutaneous nerves. The ratio between width of the excision and width of the flap is usually one-to-one.[1-4] Four types of KDPIF were described by Behan[1]. Deep fascia of the lateral margin is intact in Type I and for adequate advancement deep fascia is divided and classified as Type II. The donor site is either primarily closed (type IIA) or skin grafted (type IIB) if undue tension exists. For larger defects, two identical opposing keystone flaps may be mobilized (type III). The area underneath the flap is never undermined in types I, II, and III. However, in type IV up to 50% of the flap can be undermined subfascial to facilitate its rotation. [1,2]

With following the above-mentioned principles of KDPIF, many modifications have been done in the last two decades [5-7]. KDPIF is an attractive locoregional

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reconstructive tool offering an alternative to skin grafting and free flaps with a low complication rate[8,9].

In this study we followed both classical and modified design of KDPIF to cover lower limb defects. Aims of the study were to determine the reliability and advantages of KDPIF for lower limb defect coverage.

## Surgical technique:

After spinal anesthesia perforators were identified by hand-held Doppler and marked. A wound or tumour excision was done and wound length and width were noted. Flap was designed on side of the defect where tissue had no previous injury and greater expansibility. Though in classical design of KDPIF wound and flap width is 1:1, we took width of flap larger than wound width specially type 2 and type 4 to elevate tension-less closure. The convex border of flap was within perforator territory. Incision was first made upto deep fascia, if required, deep fascia was also included for more advancement. After harvesting flap, 2-0 cutting prolene anchor sutures were applied to wound margins to flap concave margin. Rest of the wound closed with 3-0 cutting prolene. In case of Type IV KDPIF split thickness skin graft was done for coverage of flap donor site. Splint was applied in all cases for 3 weeks. Patients were discharged by 5th – 8th postoperative day and were advised for follow up every fortnightly upto 3rd postoperative month.

For statistical analysis, Fisher Exact test was conducted with p- value <0.05.

## Results:

Among 15 cases 12 were male and 3 were female and age range was 7-65 years. Most (9 cases) of the lower limb defect were due to RTA and next most causative factors of defect were electrical burn and after Achilles tendon repair. 10 cases had exposed tibia and 2 cases had exposed dead tendoachilis; showed in Table 1. Mean wound and flap dimensions were 42.37 (±26.66) $cm^2$ and 90.5 (± 66.26) $cm^2$ respectively. Average operation time was 73.67 (±23.71) min. 7 cases were done type IIA and 4 cases were done type IV KDPIF. Among all cases, 10 cases had either of co-morbidities and 46.67% were smoker and 33.33% had diabetes mellitus. 14 flaps survived without any complications; only one flap had marginal necrosis which required STSG. Table 3 showed summary of all the flaps and their outcomes.

**Table 1: Demographic distribution of cases (n= 15)**

| Variables | | | |
|---|---|---|---|
| Sex | Male | 12 (80%) | |
| | Female | 03 (20%) | |
| Age | Mean (SD) | 334.60 (±16.44) years | |
| Etiology for defect | Electrical burn | 2 (13.33%) | |
| | RTA | 9 (60.00%) | |
| | After traumatic tendoachilis repair | 2 (13.33%) | |
| | Chronic osteomeylitis | 1 (6.67%) | |
| | Wide local excision for sarcoma | 1 (6.67%) | |
| Site of defect | Thigh | 2 (13.33%) | |
| | Proximal third of leg | 1 (6.66%) | |
| | Middle third of leg | 5 (33.33%) | |
| | Distal third of leg | 4 (26.67%) | |
| | Back of distal leg over exposed Tendoachilis | 3 (20.00%) | |
| Co-morbidities | Diabetes Mellitus | 5 (33.33%) | |
| | Smoking | 7 (46.67%) | |
| Operation time | Mean (SD) | 73.67 (±23.71) min | |
| | Range | 35- 110 min | |
| Post-operative Hospital stay | Mean (SD) | 5.67 (±0.98) days | |
| Flap survivability | No loss | 14 (93.33%) | P value (<0.05)= 0.762NS |
| | Marginal loss | 0 | |
| | Partial loss | 1 (6.66%) | |

· NS= Non significant

**Table 2: Survivability of flap**

| Flap survivability | No Loss | Marginal loss | Partial loss | P value <0.05 |
|---|---|---|---|---|
| No co-morbidity cases (n=05) | 5 | 0 | 0 | |
| Co-morbidity cases (n=10) | 9 | | 1 | 0.464NS |

NS: Non significant

**Table 3: Summary of cases (n= 15)**

| Case no | Etiology | Site | Exposed part | Wound dimension (cm2) | Flap dimension (cm2) | Type of KDPIF | Flap donor site closure | Flap loss | Secondary procedure |
|---|---|---|---|---|---|---|---|---|---|
| 1 | RTA | Right posterior heel | Tibia | 5.5X 3 | 7X 4.5 | IV | Direct closure | No loss | None |
| 2 | RTA | Middle 3rd leg | Tibia with exposed implant | 7.5X 4 | 14X 5.5 | IIB | STSG | No loss | None |
| 3 | RTA | Middle 3rd leg | Tibia | 11.4X 8 | 24X 11 | IV | STSG | No loss | None |
| 4 | chronic Osteomyelitis | Middle 3rd leg | Tibia | 10X 6 | 20X 8 | IV | Direct closure | No loss | None |
| 5 | RTA | Distal 3rd leg | Tibia | 5.6X 3.5 | 8.5X 4.5 | IIA | Direct closure | No loss | None |
| 6 | RTA | Distal 3rd leg | Tibia | 8.2X 4 | 10.5X 6 | IV | Direct closure | Partial loss (3 X 1.5 cm2) | STSG |
| 7 | RTA | Distal 3rd leg | Tibia | 7X 4 | 9.5X 6.5 | IV | Direct closure | No loss | None |
| 8 | EB | Middle 3rd right thigh | Tibia | 8X 6 | 12X 7 | I | Direct closure | No loss | None |
| 9 | TA repair (Left) | Back of leg | Dead TA | 7X 3.5 | 9X 4.5 | IIA | Direct closure | No loss | None |
| 10 | EB | Proximal 3rd of leg | Gastrocnimeus medial head | 6X 4 | 9X 4.5 | I | Direct closure | No loss | None |
| 11 | RTA | Distal 3rd leg | Exposed implant | 8X 4 | 12X 6 | IIA | Direct closure | No loss | None |
| 12 | RTA | Middle 3rd of leg | Tibia | 9X 6 | 16X 9 | IV | STSG | No loss | None |
| 13 | RTA | Middle 3rd of leg | Tibia | 7X 3.5 | 10X 4.5 | IIA | Direct closure | No loss | None |
| 14 | Wide local excision of sarcoma | left postero-lateral thigh | Biceps femoris and vastus lateralis | 11X 10 | 16X 11 | IIB | STSG | No loss | None |
| 15 | TA repair (Right) | Back of leg | Dead TA | 8X 4 | 10X 6 | II | Direct closure | No loss | None |

RTA: Road Traffic Accident; EB: Electrical burn; TA: Tendoachilis; STSG: Split Thickness Skin Graft


a.


b.

**Fig1:** Case1; a. Exposed Posterior heel following RTA b. After 6 weeks of Type IIB KDIPF coverage


a.


b.


c.

**Fig2:** a. Soft tissue defect following tendoachilis repair with exposed dead tendon b. wound excision and flap design c. Immediate KDIPF type IIA

## Discussion:

Fusion of two concepts was made in keystone flap: 1. Maintaining perforators' territory during designing two V-Y advancement flaps [10]; 2. Flap contouring like rhomboid flap or rotation flap, it is a trapezoidal shape for coverage of defect causing replacement of "Like with like". [11-13]

As multiple septocutaneous or musculocutaneous perforators are preserved, the such flap has robust vascularity and less chance of necrosis even presence of co-morbid conditions eg. Smoking and DM. In our study, 33.33% of cases had Diabetes mellitus and smoking. 14 flaps were survived without any complications and one diabetic case had partial necrosis which required STSG. This was statistically non-significant of flap survivability in relation of co-morbidities (Table-2). Pelissier P. et al[3] showed any loss of KDIPF in their study and Rao A L. et al[14] and Khouri J S. et al[11] showed their successes rate of 95% and 97% respectively. Schmidt K et al[15] showed in their review article that the survivable rate of mostly practiced, Sural artery flap for coverage of lower limb defects was 95.2%, whereas our success rate was 93.33%. So, statistically no difference of survivability rate between sural flap and KDIPF (Table 1).

This flap required short duration of harvesting (mean duration was 73.67 min ); a short hospital stay (mean 5.67 days) and versatility in lower limb defect specially thigh and leg.

Either classical KDIPF described by Behan [1] or modified KDIPs [5-7] have common elements:

1. Intra-operative rearrangement of soft tissue and skin by releasing soft tissue beneath the greater arc;
2. V-Y advancement of the skin, subcutaneous fat, and fascia at the lateral apices;
3. Preservation of as many Fascial perforators as possible;
4. Flap designed at the site where tissue laxity is more.
5. Preserve longitudinal orientation of lymphatico-venous flow-through for minimizing distal lymphoedema.

Following these principles, we made two modifications in our cases:

1. **In classical KDPIF, width of the flap was equal to that of wound (1:1). But in our cases width**

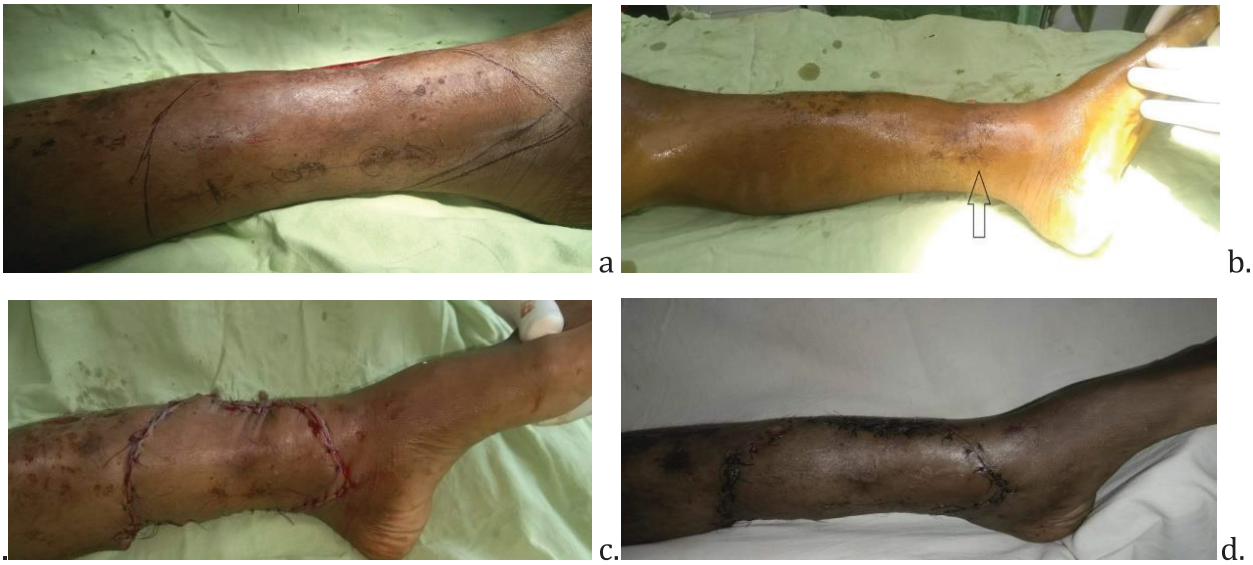

**Fig3:** a. Flap design after wound excision for soft tissue defect on distal third of leg (case 11). b. Previous scar (marked as arrow) on expandable lateral surface of distal leg; c. Immediate postoperative picture of KDIPF type IIA; d. Two weeks post operative picture.

**Fig4:** a. Soft tissue defect on middle third of leg with exposed tibia and External fixation in situ b. Flap design and "X" marked were location of perforators done by hand held Doppler.; c. KDIPF type IV and flap donor site covered with STSG d. 2 months after operation.

**was taken more than that of wound but within the perforator territories (Fig 4).** It gave some advantages, releasing tension during wound closure and less area of STSG was required for flap donor site closure in Type IIB and Type IV KDPIF. Due to tension less closure made a high level of patients' satisfaction regarding scars.

2. **Usually classical and modified KDPIF are designed in the expandable area. But in 3 cases (case no 1, 11,13), (Fig. 1,3)we harvested less expandable area in medial side of** distal third of leg based on posterior tibial artery perforators which is less expandable than lateral aspect of leg due to having previous injury on anterior or lateral surface distal leg. In another 2 cases (case no 9, 15) (Fig. 2) who had wound on back of the distal leg with exposed dead tendoachilis, flaps were designed from less expandable medial side of wound. It gave an advantage of preserving peroneal artery perforator flap territory in future if requires.

## Conclusion:

Good vascularity makes KDIPF superior to survival. And Due to Minimum Operating time, ease of execution and good outcome, KDIPF is one of the best armamentariums for lower limb wound coverage.

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