

Keystone Perforator Island Flap: A Clinical Summary of 28 Melanoma Cases from the Head and Neck Region to the Foot Where the Clinical Story is Presented with a Video Interface PowerPoint Technique

Felix Behan¹

¹ Department of Surgery
St Vincent's Hospital
University of Melbourne
Melbourne, Australia

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Correspondence

Name: Associate Professor Felix Behan

Email: felix@felixbehan.com.au

F. Behan FRACS (Gen) FRACS FRCS

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Abstract

The Keystone Perforator Island Flap and its design variations developed as a clinical necessity for reconstructing large surgical defects. The Dermatome – the embryological neurovascular delineation is the basis of the Keystone success where vessels must accompany nerves and if Flaps are designed with a neural focus, the vascularity must be there accompanying the nerves. The word 'angiotome' refers to this arteriovenous network in the Island Flap design contained within the **Dermatomal mark outs**. Even the Delto-pectoral Flap T2-T3 crosses into the Deltoid region C4 Dermatome. This fault design might explain the 10% complication rate of Distal Flap Necrosis.

KPIFs must be **Fascial Lined** supporting vascular integrity and the design resembles 2 conjoined VY Island Flaps facilitating closure.

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In the technique Axial vessels are not skeletonised. The basic Keystone Flat design must retain the middle 1/3 attachment to the deep fascia. This *aide memoir* is sufficient and has been applied successfully in over 3,000 cases over 20 years.

This wide range of clinical experience digitally recorded produced a range of observational findings. A **Reactive Hyperaemia** in the Flap which takes up to 15 minutes to become evident producing important consequences. It allows KPIF Flaps to be closed under **Tension** as the Perforator zones (Perforazones) are oriented vertically with a stronger hydrostatic supply than the horizontally aligned subdermal plexus. It is surmised to be an **autonomic reflex**. Additionally oedema in the KPIF is rarely observed and could possibly be a sympathetic affect also with the Lymphatic supply opening up channels to reduce oedema of those chronic wounds where lower limb reconstruction by the KPIF has been employed. Reactive Hyperaemia is evident in irradiated tissue. It allows one to break another rule in Plastic and Reconstructive Surgery in **Irradiated Tissue** where loco-regional reconstruction is contraindicated.

Tissue match is important and 'like for like' in the Gillies Principle is maintained where the 'next best tissue is the next best tissue'. This contributes to a sound **Aesthetic** outcome.

Additionally these **KPIF Flaps reconstructions are pain free** even though tension is noted. As a simple linear surgical wound is almost anaesthetic along the margin and recovers in 3 months, the Quadrangular KPIF produces the same result for that complete dimension. This is explained by the simple fact that temporary interruption of somatic innervation in this quadrangular design recovers over a few months, in the same way as any longitudinal incision regains its nerve supply.

The PACE acronym (Pain free, Aesthetics, Complications and Efficient timescale) characterise this reconstructive idea. Closure under Tension is the norm of wounds that cannot be closed directly without a KPIF. Tension on the surrounding tissues are the means of coaptation to achieve wound closure. Any simple surgical wound that can be closed directly does not show the PACE characteristics. The KPIF may have some intrinsic expansion but closures are only achieved by peripheral tissue apposition around this island flap. Any argument criticising this reconstructive technique for smaller excisions may be valid but to suggest this applies to all KPIF reconstructions, even for commercial gain rather than for surgical integrity is critically sceptical if not iconoclastic.

Key words: Keystone Design; Reactive Hyperaemia; Pain Free Procedure; Tensional Closure; Aesthetic Appearance; Irradiated Tissue

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Introduction

The clinical use of the Keystone Perforator Island Flap (KPIF) in surgical reconstruction continues to be re-evaluated from its initial concept for use in small mitotic lesions to major reconstructions all over the body.

Definition of KPIF

The Keystone shape is an architectural design, arch-like, not dissimilar to the early historic buildings like the Colosseum built by Titus in 70AD using this Moorish concept that the arch provides structural support to allow a high rise construction. Metaphorically such an arch is the basis of this reconstructive tool which allows extensive applications all over the body. My colleague Alan Breidahl suggested the word Keystone in the early development phase of the concept design in the late 1990s as one of the team members of the Plastic Unit at the Western Hospital, Melbourne.

The composition of the KPIF

The Keystone concept structurally consists of skin, fat and fascia, with neurovascular and lymphovascular integrity, all designed with the dermatomal markouts of the body ensuring an embryological basis and design for such a reconstructive tool. It has VY triangular apices at the extremes having a close resemblance to the original VY Island Flaps. Such flaps were designed by Friedrich Dieffenbach, a German surgeon of the University of Königsberg, of the 1840s. Schematically when one joins the diagonal extremes across centre of the Keystone arch this creates apparently two conjoined VY Islands. This is the basis of its vascular integrity and clinical success which is based randomly, avoiding specific exploration of perforated (perforasomes) sources

which may skeletonise the sources of autonomic and lymphatic support.

The vascular and neural basis

The work of Michel Saint-Cyr delineating specific perforator sources (perforasomes) complements this reconstructive technique designed within the dermatomes an embryological concept. In human development the generation of neural strands – future nerves – from the notochord around the coelom stimulated vessels to accompany these radially developing neural structures. Therefore if there is a nerve supply there must be a blood supply and if flaps have a design within neural specificity (KPIF within the dermatomes) the neurovascular support must have an integral base. However in the process of skeletonising vascular axes as one sees in Perforator Propeller Flaps kinking is a common occurrence accounting for a figure of 47% complication rate.¹

The perforator sources are not skeletonised in my technique and as long as the undermining of the fascial lined KPIF retains one third (1/3) of deep attachment. All the clinical cases illustrated on video have been designed and executed in this manner without Doppler localisation. From an observational point of view one assumes this regular characteristic featuring reactive hyperaemia as illustrated would imply that the sympathectomy effect has been created to explain this reactive hyperaemia. This develops usually within 15 minutes of raising the fascial lined KPIF. The Red Dot Sign is a regular clinical finding where the suture sites in the flap bleed more on the flap side than the surrounding insert area. Reflecting this hypervascularity means that the flaps can be closed under surgical tension and the initial white stress lines across the flap are only fleeting because the perforator circulation

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(perforasomes) are vertically orientated. This bypasses the subdermal plexus which is unable to handle closure under tension and thus is the basis of Flap necrosis seen when tension on reconstruction is developed. Associated with this presumed autonomic supply then lymphatic integrity could also be retained as post operative oedema is a rare phenomena in KPIF reconstructions. Another important aspect in this reconstructive technique is that all venous tributaries where possible are retained and repaired should they be damaged surgically or inadvertently. Also we must not forget McGregor's famous comment years ago that more flaps die of venous stasis than arterial insufficiency.

Thus in summary with an intact vascular system associated with autonomic and somatic support including lymphatic drainage the Gillies principles of 'like for like' and the 'next best tissue is the next best tissue' in any reconstructive design principle are historically maintained.

Historical perspectives

The word 'angiotome' and its vascular network contained within the dermatomal markouts is present in Dorland's Medical Dictionary. It defines it as a vascularised segment. The original publication for Angiotome Concept² came from work done by the author as a Bernard Sunley Research Fellow at the College Surgeons of London in 1972. Here this research was one of the initial investigations using radiocontrast dyes on cadaver investigations. The paper was presented at the International Plastic Surgical Meeting in Madrid in 1973 under the Chairmanship of Sir William Manchester of New Zealand. This research paper, co-authored with Ian Wilson, was subsequently published by the Royal College of Surgeons, London.

Clinical perspectives

This reconstructive tool has undergone a clinical metamorphosis in design and shape over the last 20 years and is governed by the design of the surgical defect creating rectangular and even Omega variants since its initial concept and use from 1995. The initial case of keloid scar needing repair vertically across the cubital fossa meant that Island flap with VY Design Apices allowed rotation and transverse alignment and the closure was completed with VY apposition at either extreme. Needless to say the satisfactory result to improve elbow function became the basis for ongoing applications throughout the body based on that elementary principle – the fascial lined flaps must be within the dermatomal presence.

The easiest places to gain confidence in the use of this KPIF technique is over the **limbs** in those parts where the **muscle bulk** allows compressional closure of the Keystone arch even under tension – for example the muscle substances of the forearm, then the upper limb between shoulder joint and elbow. The muscles of the thigh and the calf are other sites where KPIF closure is relatively easy. However circumferential KPIFs are totally contraindicated as closure in a vertical axis results in tensional disintegration yet when biopsy excisions are done with this alignment it can be a difficult KPIF closure.

Where major defects are involved and closure, even under tension over **joints**, this KPIF closure is still possible and the undermining at the fascial level with or without grafting can achieve wound closure. However the principle of one third (1/3) attachment must obtain. In the **head and neck** region major parotid defects can be closed with relative ease with direct apposition over the cheek including this Smas layer. For **larger head and neck defects** the cervical submental dermatome

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C2/C3 allows the island flap to be rotated from the loose neck tissue into the preauricular cheek defect even as high as the zygomatic arch. **In the back**, especially over the scapula region, the U-shaped horse shoe variant design allows the limbs the arch to close the defect when designed along the intercostal perforator input ~ T4-T8. To repeat, the KPIF is designed along the intercostal perforators undermined in its proximal and distal one thirds and closed into a U to achieve closure of large scapular defects as illustrated in the video below.

Scientific evaluation

Quoting from Peter Doherty's text *The Knowledge Wars*³ he summarises the principles of scientific development enumerating concepts establishing authenticity while assessing the following points:

- Probing ideas;
- Designing experiments;
- Pursuing observational strategies;
- Making measurements;
- Drawing valid conclusions from reproducible data.

Clinically, as Sir William Osler said, observation is the basis of scientific advancement. This has been the background of scientific evaluation throughout this extensive 20 year experience (over 3,000 cases). These have been done all over the body and limited over the scalp where reconstructions using axial Island Flaps can be applied. All reconstructions over this period have been based on clinical experience producing from these observations reproducible data. Thus, this success is the basis of the documented data recorded photographically and has been the basis of two text books and 14 articles as summarised on the Mayo Clinic publication co-authored with Saint-Cyr.⁴ Future text books will adopt this teaching

format combining PowerPoint presentation and video supplementation. The clinical success of the KPIF becomes the foundation of this evidence-based process which simplifies reconstruction.

Complications are rare. Tight closures on any region with premature removal of sutures can be a clinical setback. My working rule in this single layer wound closure technique is that the continuous everting nylon epidermal sutures are clipped at 7 days, at 14 days some mattress sutures can be removed providing they are not tension points, and at 21 days the **locking mattress sutures** can be discretely removed. Should bleeding occur in this staged wound dressing technique cease removal of sutures and bring the patient back in a week as they are evidently slow in healing. The locking mattress sutures are usually located along the mid-points of the arch of the KPIF (convex and concave sides). To avoid wound breakdown issues, details of wound dressings must be part of any discharge summary instructions. This applies particularly when wounds are dressed at outside clinics and the suture removal pattern needs to be cautiously supervised to avoid wound breakdown, a complication for those not conversant with the technique of single layer tension closure.

Complications have arisen with vascular impedance on the dorsum of the foot and therefore grafting of any secondary defect is mandatory. Diabetics are a particular worry and should be handled with absolute caution without being too adventurous. Again, split skin grafts help to relieve any tensional alignments.

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In summary the KPIF intrinsic characteristics are listed below:

- The fascial line dermatome creates a pattern ensuring vascular integrity from a specific or a non-specific random perforator source.
- The **suprafascial and infrafascial vascular support** have been verified scientifically in the angiographic experiment by Saint-Cyr.
- The transverse dimensions of the flap with perforator support permit **closure under tension** of the central area.
- **VY Apposition** proximally and distally permit closure around the apices to create an **aesthetic outcome**.
- The initial appearance of a **cyanotic phase with white lines of tension** become slowly vascularised and the perfusion reflects a possible sympathectomy effect of creating Island Flap reconstructions.
- The initial cyanotic phase is replaced with a hyperaemic development which reflects increased perfusion of arterialised blood throughout the subdermal plexus eliminating the white lines of tension.
- The hypothesis of the increase in vascular perfusion is based on the clinical findings established years ago when a lumbar sympathectomy resulted in a pink foot within a few hours.
- In the KPIF these vascular effects are documented photographically and the time frame of its development is usually within 15 minutes.
- This **increased vascular perfusion** aids healing with minimal evidence of flap necrosis. KPIF reconstructions on the dorsum of the foot and in particular in diabetics and such cases are to be taken as a warning of potential complications. The issue of smoking is also a contraindication when one observes this

traditional restriction in any form of flap reconstruction.

- The dermatomal mark out with non-specific neural connections has the advantage that the KPIF is a pain free reconstructive tool while the patient's only assessment is 'the tissues feel tight.' Following recovery normal somatic supply with **protective sensation** is a characteristic of the KPIF.
- The KPIF's likewise avoid pin-cushioning oedema, a former criticism of island flaps. Could this be a reflection of a sympathectomy effect on the lymphatic drainage facilitating removal of oedema fluid? It is hypothesized that the dilation of the lymphatic bed thus minimising oedema may well be a similar effect as the vascular hyperaemic changes and red dot sign characteristics of the KPIF.

The acronym PACE crystallises the above:

- P** Pain: reconstructions are tight but pain free which the patient appreciates but does not complain.
- A** Aesthetics: the aesthetic appearance of using like with like in reconstruction, repeating the Gillies Principle, gives an acceptable outcome.
- C** Complications: are fairly unusual from a vascular point of view (Diabetics and the Dorsum of the foot are treacherous areas to be deleted and avoided).
- E** Economics: the time frame for operations may last 60-90 minutes compared with the different time frames for microsurgery and as Benjamin Franklin said two centuries ago: Time is money.

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Case Series illustrated as a PowerPoint Presentation using KPIF and its architectural variations (click on link for individual video)

Introduction videos

1. [Case Studies](#)
2. [Felix Behan introduction to the design principle and its architectural variations](#)
3. [Keystone overview and its design variations](#)
4. [A clinical synopsis acronym covering:](#)
 - i. Pain level
 - ii. Aesthetic outcome
 - iii. Complications
 - iv. Efficiency from time perspective

Cases videos

[Case 1:](#) Introduction to using KPIF with melanoma posterior neck.

[Case 2:](#) Neck, melanoma and the KPIF design within the c2 c3 dermatomes undermining leaving a third attachment along sternocleidomastoid muscle: no Doppler localisation.

[Case 3:](#) Neck, anterior infraclavicular random perforators for the KPIF.

[Case 4:](#) Scalp – vertex melanoma of the scalp, secondary disseminated into the right neck – following clearance the cyanotic flap is hypervascularised by creating an island leaving a third deep attachment. Full survival.

[Case 5:](#) Melanoma – lower limb over posterior calf above the tendo achilles.

[Case 6:](#) Face – preauricular region melanoma closure with a cervico submental KPIF. Base rotated on random sternocleidomastoid perforator.

[Case 7:](#) Hand – first dorsal interosseous region melanoma – poor biopsy orientation closure with a circumferential KPIF with hand in Ulna deviation.

[Case 8:](#) Right cheek melanoma – closure with a submandibular KPIF closure.

[Case 9:](#) Right cheek melanoma – Parotid melanoma defect 10 x 9 cm closure by supraclavicular KPIF with a third attached beyond the block dissection.

[Case 10:](#) Right cheek melanoma in an irradiated field – KPIF can be used in irradiated field reflecting the hyperaemic phase in spite of subdermal fibrosis caused by the XRT, the vertical orientated perforators bypass this fibrosis to ensure healing.

[Case 11:](#) Right parotid melanoma – direct closure SMAS layer KPIF.

[Cases 12 and 13:](#) Groin – Recurrent melanoma following failed XRT. Primary acral lentiginous melanoma on the sole of the foot. The quadrangular L2 KPIF of the anterior thigh closes the defect after division Tensor Fascia and medial deep Fascia KPIF.

[Case 14:](#) Lateral calf – melanoma – grafting of the secondary defect in along the peroneal compartment because of tension.

[Case 15:](#) Left calf upper third – peroneal KPIF creating a horse shoe variant – U shape – and preservation of the superficial peroneal nerve and split skin graft of secondary defect.

[Case 16:](#) Angle of the jaw – large melanoma over the parotid. Closure of the defect with a cervico submental KPIF.

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[Case 17:](#) Angle of the jaw – Melanoma of the parotid in an 80-year-old, closure by creating island KPIF by delineating the V2 dermatome to hypervascularise it. The whole wound is closed directly including tensional apposition over the parotid.

[Case 18:](#) HMF L1MM of the left cheek – Drape procedure, delayed reconstruction after pathology evaluation. Clearance and closure of the cervico submental KPIF based on random sternocleidomastoid perforators.

[Case 19:](#) Calf melanoma – the standard for learning the art of the KPIF closure over muscles. Calf, thigh, forearm and biceps region are the easiest places to learn this KPIF technique (deep fascia must be divided to create a bridge flap).

[Case 20:](#) Right malar melanoma – superior orientation of the KPIF along the v2 division delineation allows direct apposition as an alternative to a cheek rotation flap in a young patient.

[Case 21:](#) Right Calf – standard KPIF in a young female – orientated according to the biopsy orientation – single Redivac drain tube covering both sites is folded on itself – draining both defects.

[Case 22:](#) Heel acral lentiginous melanoma in an 80-year-old patient, planta fascia KPIF. Based on medial planta neurovascular circuit leaving the medial third attachment for the KPIF, no secondary defect graft needed, although planned.

[Case 23:](#) Scapula region melanoma – Sarcamo of the scapula with auxillary clearance – Omega KPIF fascial lined variant leaving the middle third attached to T6-T8 intercostal perforators orientation. Patient walked the Himalayas 4-5 weeks post-op.

[Case 24:](#) Recurrent melanoma of the parotid – sacrificing the facial nerve. KPIF principle and V2 dermatome is the mark out for the island flap reconstruction to hyper vascularise the cyanotic tip. Delayed tarsorrhaphy 12months.

[Case 25:](#) Forehead melanoma and reconstruction with V2 dermatome islanded flap to hyper vascularise the tip, to reach the medial eyebrow region for a defect 10 x 6 cm.

[Case 26:](#) Left forehead desmoplastic melanoma. KPIF of the superficial temporal artery in a smoker. The sarcoma clearance was achieved, but this may contributed to the distal flat necrosis which took 4 weeks to heal.

[Case 26:](#) Complication.

[Case 27:](#) Complications of the calf – delayed healing in a KPIF for recurrent melanoma following XRT, then groin dissection and peripheral oedema.

[Case 28:](#) Forehead melanoma – slow healing KPIF in a patient with chronic lymphatic leukaemia.

[Keystone \(KPIF\) Reconstructive Concept for Major Melanoma Defects – An Aesthetic Perspective.](#)

A total of 28 cases representing a range from the series of up to 3,000 cases established over 20 years when the first KPIF was done in 1995.

This is the work presented at the 17th International Perforator Conference in Sydney, Australia on 10-12 November 2016 with the focus here on Melanoma Management.

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Further reading

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