



THE KEYSTONE CONCEPT IN ROMAN ARCHITECTURE AND ITS SURGICAL ANALOGY: APPLICATION OF THE KEYSTONE PERFORATOR ISLAND FLAP IN TWO COMPLEX TRUNK RECONSTRUCTIONS

Dr. Pushkar Deshpande*

MBBS, MS, MCh (Plastic Surgery), The Aesthetic Hub, Pune, Maharashtra, India. *Corresponding Author

Dr. Sushrut Tated

MBBS, MS, MCh (Plastic Surgery), The Aesthetic Hub, Pune, Maharashtra, India.

Dr. Surajsinh Chauhan

MBBS, MS, MCh, DrNB, (Plastic Surgery), The Aesthetic Hub, Pune, Maharashtra, India.

ABSTRACT

Background: The architectural keystone - the central locking stone of Roman arch provides stability by distributing compressive forces laterally through the arch. Inspired by this structural principle, Behan introduced the Keystone Perforator Island Flap (KPIF), a perforator-based fasciocutaneous flap offering multidirectional tension redistribution.^[1,2] **Objectives:** To highlight the relationship between the Roman architectural keystone and KPIF biomechanics, and to present two challenging trunk reconstructions: (1) central back implant exposure (2) lateral-trunk saree cancer defect. **Methods:** Two patients underwent KPIF reconstruction (Type II). Flap design, perforator preservation, and clinical outcomes were evaluated. **Results:** Both flaps survived fully. The central-back implant remained salvaged without explantation. The saree cancer defect achieved durable, tension-free closure with excellent contour. **Summary:** The Roman keystone's principle of structural locking and lateral force distribution is mirrored in KPIF mechanics. The flap provides a dependable option for complex trunk reconstruction including implant exposure and oncologic defects.

KEYWORDS : Keystone flap, Reconstruction of trunk, Saree cancer

INTRODUCTION

The keystone in Roman architecture is the wedge-shaped central stone placed at the apex of an arch.^[3] it locks surrounding voussoirs in place and redirects compressive forces laterally into the supporting piers. This innovation central to Roman bridges, aqueducts, and monumental gateways allowed the construction of wide, load-bearing arches with remarkable longevity. In modern reconstructive surgery, the same biomechanical philosophy inspired Behan's Keystone Perforator Island Flap (KPIF)^[4]. By preserving perforators and allowing controlled fascial division, the flap behaves like a biological arch: stabilizing the closure while redistributing tension across multiple vectors. This paper presents the architectural-to-surgical analogy and reports two cases where KPIF provided durable coverage in demanding trunk defects. Keystone Perforator Island Flap (KPIF) is a fasciocutaneous perforator-based V-Y advancement flap based on predictable musculocutaneous perforators of the trunk, including intercostal, lumbar, and superior gluteal systems. In KPIF, central stone stabilization of the arch is achieved through intercostal, lumbar, and superior gluteal perforator systems, ensuring stable flap perfusion, lateral force distribution, effective V-Y advancement, prevention of flap collapse and wound dehiscence, all with minimal undermining. KPIF has four types, Type I: No fascial incision, Type II: Fascial division (most common for trunk), Type III: Double opposing keystone flaps, Type IV: Islanded flap.

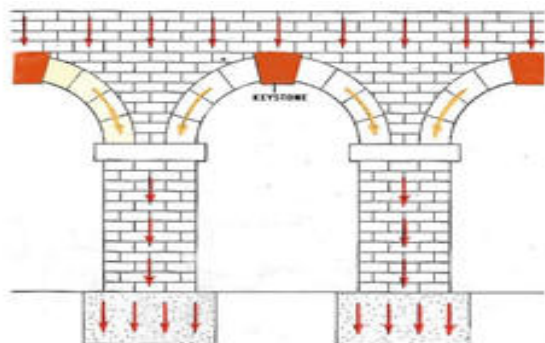


Figure 1: Roman Architecture showing Keystone and Distribution of forces.

Case Reports

Case 1: Central back implant exposure after trauma patient. A 68-year-old male with a dorsal implant for spine referred from orthopedic department with implant exposure following skin Defect, it was located Central thoracolumbar back, Size: 36 × 12 cm, partial implant exposure with surrounding tissue fibrosis. Surgical Technique-Type II KPIF designed adjacent to the defect along known intercostal/lumbar perforator pathways, Deep fascia divided circumferentially for mobility, Minimal undermining to preserve perforators, V-Y advancement achieved complete implant coverage without explanation. Outcome- Complete flap survival, No infection or seroma, Excellent contour and implant stability at 6-month follow-up.



(A) Wound Defect



(B) Debrident and Flap Planning



(C) Immediate Result



(D) Long Term Results

Case 2: Saree Cancer^[5] (Squamous Cell Carcinoma) of Lateral Trunk Patient. A 58-year-old woman with chronic irritation along saree waistband developed a well-differentiated SCC (saree cancer). Defect- Location: Right lateral flank, Size after excision: 9 × 7 cm, Exposed muscle fascia; rigid surrounding skin. Surgical Technique-Type II flap

designed on both sides of the defect, Perforators from lumbar and superior gluteal systems preserved V-Y advancement achieved tension-free closure. Outcome- Full flap survival, Smooth contour, no dog-ears, no marginal necrosis, and Comfortable return to saree use at 4 weeks, Clear margins; disease-free at 1-year follow-up.



(A) SCC - Sari Cancer



(B) Keystone flap planning



(C) Immediate Post-Operative results



(D) Late Post-Operative results

DISCUSSION

The Roman keystone distributes structural loads to maintain arch stability. Similarly, KPIF distributes closure forces across multiple soft-tissue vectors, minimizing tension at the defect edge. Advantages of KPIF demonstrated in these cases: Reliable perfusion even in fibrotic or irradiated tissues, avoided implant removal in Case 1, achieved oncologic, tension-free closure in Case 2. No microsurgical expertise required, reduced operative time and donor morbidity. KPIF is therefore a compelling option for trunk reconstruction where regional tissue mobility is limited.

CONCLUSION

The Roman keystone principle central stabilization with lateral force distribution translates elegantly to the KPIF technique. Both cases demonstrate the flap's reliability for: Implant exposure of the central back, large oncologic defects such as saree cancer. KPIF remains a structurally sound, conceptually elegant, and highly versatile reconstructive method.

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