

# Role of Hybrid Reconstruction Ladder in Keystone Flap

Barath Kumar Singh P<sup>1</sup>, Ravi Kumar Chittoria<sup>2</sup>

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## Abstract

The development of novel and inventive tissue regeneration strategies has been sparked by complex wound patterns. A multi-disciplinary team has successfully adopted advanced reconstructive methods combined with modalities from regenerative medicine to enhance the results of difficult reconstruction. These procedures, known as "Hybrid reconstruction ladder," combine conventional reconstruction techniques with regenerative medicine applications. This review article provides a summary of the benefits of using a hybrid reconstruction ladder to create a healthy wound bed for a keystone flap.

**Keywords:** Keystone flap; Hybrid reconstruction ladder.

## INTRODUCTION

The fundamental idea of reconstructive techniques being prioritised by complexity has been kept and spread in many ways as plastic surgery has slowly evolved over time. The majority

of descriptions begin with secondary intention closure, then move on to direct closure, local flaps, and remote flaps. Finer differences between local, regional, and free flaps, as well as inserting tissue growth somewhere along the spectrum, have been made by a number of authors.<sup>1,2</sup> The complicated wound pattern has spurred efforts to develop novel and ground breaking tissue regeneration methods. To improve results, a multidisciplinary team has successfully adopted modern reconstructive procedures combined with regenerative medicine modalities. These procedures are referred to as "hybrid reconstructions" because they mix conventional reconstructing techniques with regenerative medicine applications. The hybrid reconstruction model (Fig. 1) aids in maximizing the function while minimizing the disability and morbidity associated with traditional reconstruction.

**Author Affiliation:** <sup>1</sup>Senior Resident, Department of Plastic Surgery, <sup>2</sup>Professor & Head of IT Wing and Telemedicine, Department of Plastic Surgery & Telemedicine, Jawaharlal Institute of Postgraduate Medical Education and Research, Pondicherry 605006, India.

**Corresponding Author:** Ravi Kumar Chittoria, Professor & Head of IT Wing and Telemedicine, Department of Plastic Surgery & Telemedicine, Jawaharlal Institute of Postgraduate Medical Education and Research, Pondicherry 605006, India.

**E-mail:** drchittoria@yahoo.com

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Fig. 1: Hybrid reconstruction ladder

**MATERIALS AND METHODS**

In this case report, 25 year old male, Patient was apparently well 7 years back when he fell from tree and developed acute flaccid paralysis of lower limbs with loss of sensation. Patient underwent spine surgery. He developed bed sores at bilateral gluteal region for last 2 months. Initially, the swelling increased in size and ruptured, leaving a raw area. Wound gradually enlarged. Then the patient came to JIPMER Hospital with the chronic non healing Pressure ulcer over the bilateral gluteal region (Fig. 2).



Fig. 2: Non healing ulcer over Bilateral gluteal region at the time of admission.

The pressure sore/ulcer involving the bilateral gluteal region has unhealthy granulation tissue, not fit for flap cover at present. The wound bed was prepared with regenerative therapies to improve the

healthy granulation tissue. Hydro jet debridement done to remove the unhealthy slime layer over the granulation tissue. Autologous Hemoglobin spray, Vitamin D and collagen granules, Autologous platelet rich plasma, Dry collagen scaffold dressing, Prolotherapy, Negative pressure wound therapy, Low level laser therapy (Fig. 3-10) was used in the preparation of wound bed and for better flap survival.



Fig. 3: Hydrojet debridement and Hemoglobin spray



Fig. 4: Vitamin D and Collagen granules



Fig. 5: Prolotherapy for wound bed preparation



Fig. 6: Low Level Laser therapy for wound bed preparation



Fig. 7: Collagen scaffold dressing for the wound



Fig. 8: Sucralfate therapy for wound bed preparation



Fig. 9: NPWT therapy



Fig. 10: ETWC - External wound closure system

The local keystone flap based on the perforator on the lateral side of the ulcer was planned. After assessing the perforator on one side of the defect, defect was covered with keystone perforator flap. Post-operative care for the flap was done with innovative ring splint made from cotton roll and pad made into a ring and fixed around the flap site so that even if the patient lies flat flap site was protected by the splint from direct pressure over the skin grafted site. Post-operatively keystone flap was given low level laser therapy, APRP injection to improve the survival of the flap (Fig. 11).



Fig. 11: APRP over the keystone flap

The wound healed well at the time of discharge (Fig. 12).



Fig. 12: Healed wound at the time of discharge

## RESULTS

Wounds which are difficult to reconstruct and healing are approached effectively with hybrid reconstructive ladder. It helps in fasten the healing rate and the patient has good compliance with the regenerative therapy. The regenerative medicine plays a major role in the hybrid reconstructive ladder and it helps in rescue the patients when the reconstructive options for the patients are limited. Regenerative therapies provide the healthy environment for improving the survival of the flap.

## DISCUSSION

The reconstructive ladder was a term coined by plastic and reconstructive surgeons to describe levels of increasingly complex management of soft tissue wounds. Theoretically, the surgeon would utilize the lowest part of the ladder that is, the simplest reconstruction technique to address a clinical reconstructive problem. The reconstructive surgeon would move up the ladder as a more complex or suitable method was required for a given reconstruction problem.<sup>3-5</sup> In this case as the patient is a known case of Pressure sore involving

bilateral gluteal region. The patient underwent local keystone flap cover based on perforator. A hybrid reconstructive ladder that augments the traditional reconstructive ladder with regenerative medicine modalities helps in improving unhealthy wound for better flap survival. There were improved outcomes at each step on the reconstruction ladder and these modalities may allow for the expansion of indications for each step on the reconstruction ladder. The study effectively employed dermal regenerates, soft tissue regeneration techniques, biologic scaffolds<sup>6</sup>, fat grafting techniques and adipose derived stem cells in a number of reconstructions. Dry collagen was used as a scaffold for tissue regeneration of the wound bed for further intervention.<sup>6,7</sup> Prolotherapy believe that the injection of hypertonic dextrose causes cell dehydration and osmotic rupture at the injection site that leads to local tissue injury that subsequently induces granulocyte and macrophage migration to the site, with release of the growth factors and collagen deposition. In vitro studies have shown that even concentrations as low as 5% dextrose have resulted in the production of several growth factors critical for tissue repair. Some of these growth factors include PDGF, TGF- $\beta$ , EGF, b-FGF, IGF-1, and CTGF.<sup>8</sup> The reconstructive grid is a dynamic construct that takes into account the multiple reconstructive options available to the plastic surgeon. It also takes into consideration factors that help the reconstructive surgeon determine the best possible option to achieve the three reconstruction goals, namely, form, function, and aesthetics. The factors that aid the judgment of a reconstruction specialist, including wound complexity, surgeon skill, resources (and technology) available, and patient requests, form the boundaries of the reconstructive grid. Low Level Laser Therapy (LLLT) is one of the proposed modalities to improve wound healing and scar quality. LLLT is claimed to increase collagen synthesis, decrease inflammation and has a positive impact on scar remodeling. Negative Pressure Wound Therapy involve removal of exudates and infectious materials and contraction of wound margin. NPWT has been shown to be safe and effective in post debridement wounds.<sup>9</sup> Hence NPWT was started, and size of the wound was measured at the time of change of dressing. Platelets act as regulators of inflammation, angiogenesis, cell migration, and proliferation with the release of various growth factors and anti-inflammatory cytokines which is thought to help in faster and better healing of the wounds. Autologous platelet rich plasma (APRP) has growth factors which when

injected in the wound site or sprayed, act at the intracellular level to bring about cell proliferation and healing of a wound. All extracts of *Centella asiatica* facilitate the wound healing process in both incision and burn wounds. Asiatic acid in the ethyl acetate extract seemed to be the most active component for healing the wound.<sup>10</sup> Keystone is a peg shaped, main stone which supports the arch in Greek architecture. Because of the shape the flap designed, it is known as keystone flap. There are various types that have been described.<sup>11</sup>

### ***Type - I***

The standard flap design and closure is suitable for defects over most areas of the body up to 2 cm in width

### ***Type - II A: Division of deep fascia***

For larger areas of reconstruction, located over the muscular compartments, the deep fascia over the muscular compartment is divided along the outer curvature of the flap to permit further mobilization of the keystone flap

### ***Type - II B: With split skin graft to secondary defect***

Where excess tension exists, the secondary defect may be skin grafted

### ***Type - III: Double keystone flaps***

For considerably larger defects (5-10 cm) a double keystone design can be done to exploit maximum laxity of the surrounding tissues.

### ***Type - IV: Rotational keystone flap***

Occasionally to facilitate rotation across a joint contractures or compound fractures with exposed bone, the keystone flap is raised with undermining up to 50% of the flap subfascially. The perforator support is derived from the attached part of the flap.

Keystone flap was initially described for lower extremity defects.<sup>11</sup> There have been reports of the used of this design for trochanteric pressure ulcers. Since our patient had partial recovery of paraplegia, he walks with support and can be in sitting position for long time. This has led to ischial pressure ulcer. A versatile flap was required, which covered the bony prominence. As he had recurrent pressure sore, it was thought to be prudent to preserve the

muscular flaps for future. We have used the type 1 keystone flap for the pressure ulcer since we felt the fascio-cutaneous flap would give an adequate cover and also leave the other options as our life boat flap. We have found this flap is easy to design and owing to the surrounding skin laxity in the gluteal region the donor site was closed primarily.

## **CONCLUSION**

The application of regenerative medicine therapies in the preparation of wound bed before complex reconstruction significantly aided in improving reconstructive outcomes. Hybrid Reconstruction Ladder is continuing to evolve and may become the standard of care for effective management of composite tissue wounds and chronic non healing ulcers. Even though there are various flaps described in literature for ischial pressure ulcer, keystone flap, is a versatile flap which may be added to the armamentarium of treatment of pressure ulcers. However larger sample size is required for identifying the absolute indications for the use of keystone flap and the possible complications. This has to be applied to the multiple number of cases for the assessment of the hybrid reconstructive ladder in complex wounds for identifying the limitations.

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