Keystone-designed perforator island flaps for reconstruction after chest keloid excision: A retrospective case series

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Abstract

Objective: We retrospectively evaluated the efficacy and safety of keystone-designed perforator island flaps for chest keloid reconstruction.

Methods: We reviewed consecutive patients who received keystone flap reconstruction after chest keloid resection between January 2017 and February 2018. The patient demographic data, defect size, flap size, complications, and recurrence were recorded.

Results: Thirty-eight patients were evaluated in this retrospective case series. After keloid resection, dimension of wound defects was 5.5 - 9.5 cm × 9.5 - 12.5 cm, with an average dimension of 7.3 cm × 10.7 cm. The dimension of keystone flaps was between 6 - 10 cm × 20 - 34.5 cm, with an average dimension of 7.5 cm × 25.5 cm. The flaps healed smoothly without any complication. There was no keloid recurrence with 15 months of follow up. 89.4% of the patients had good outcome with no apparent scarring, and 10.6% patients had satisfactory outcome with localized scarring.

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Conclusions: Keystone-designed perforator island flap is an effective and reliable method for reconstruction following chest keloid resection.

Abbreviations: KPIF = keystone perforator island flap, IMAF = internal mammary artery perforator

Keywords: chest, flap, keloid, keystone flap, perforator, reconstruction

1. Introduction

Keloids are pathological scars extending beyond the original wound borders, which is common in Asians.^[1] As a site with high tension, the anterior chest accounts for 48.9% of keloids according to a previous report.^[2] Although small keloids could be treated with conservative therapies such as corticosteroid or laser,^[3] larger keloids should be treated with surgery and radiotherapy.^[4]

According to our published algorithm for chest keloid management, local flaps or internal mammary artery perforator propeller (IMAF) flaps were used to repair the defect.^[5] Other reconstructive options, such as Z-plasty^[6] and fortune cookie flap^[7] were also reported in literature.

Since its first report in 2003,^[8] the keystone perforator island flap (KPIF, also called keystone flap) has been popular for its simple design, versatile application, and reliable blood supply.^[9] One of the advantages of keystone flap include even distribution of tension over the entire incision length of the flap,^[10] which is ideal for reconstruction of the wound after keloid resection.

The objective of this study is to introduce our reconstruction experience of keystone flaps for reconstruction of the defect after chest keloid resection.

2. Materials and Methods

2.1 Patients

The medical records of consecutive patients with chest wall keloid who received reconstruction with keystone flaps following keloid resection from January 2017 to February 2018 were retrospectively reviewed. We retrieved each patient's demographic data, defect dimensions, flap dimensions, complications, and recurrence information through medical records.

This study was adhered to the tenets of the Declaration of Helsinki, and approved by the

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Institutional Review Board (IRB) of Peking Union Medical College Hospital. All the patients signed written informed consent for permission to publish.

2.2 Surgical technique

The first step was complete resection of the chest keloids. After meticulous hemostasis, the defect size was identified with a ruler. The longest dimension was defined as defect length, and the dimension perpendicular to it was defect width. The tissue surrounding the defect was tested, and the side with greater laxity was chosen for flap design. As illustrated in Figure 1, one of the incisions of the flap is the same with the incision of the defect, and two shorter limbs of the flap were perpendicular with it.^[11] The width of the flap was designed to be equal to or slightly larger than the defect width when surrounding tissues have less laxity.^[12] When feasible, the flaps should be designed along aesthetic units,^[13] such as the inframammary fold.

After skin was incised down to fascia circumferentially, the flap was dissected carefully to avoid injuring the perforators within it. In order to improve its motility, partial or complete division of the deep fascia was performed. The flap was then moved towards the defect. The two shorter limbs of the flap were mobilized in a V-Y fashion, perpendicular to the direction of flap movement towards the defect. The area of the flap and the original defect was covered with the keystone flap. To minimize tension of the incision, tension reduction suture was used as previously reported.^[14] Skin incision closure was performed with continuous subcuticular nylon sutures to avoid suture marks.

2.3 Postoperative care

There were two fractions of radiotherapy, on the first and eighth postoperative day, respectively. External electron beam irradiation was delivered with 8-9 Gy per session. Sutures were removed 2 weeks after surgery. Silicone gel sheets were applied on the incision for 6 to 12 months. Compression therapy was continued for 12 months. The patients were followed up every 3–6 months. On the last follow up visit, outcome was evaluated by the doctor as good (no apparent scar growth), satisfactory (partial scar growth), or poor (keloid recurrence).

3. Results

Thirty-eight patients were identified in this retrospective study, with a mean age of 48.3 years (30-65 years). Twenty-seven patients received steroid therapy, nine patients had resection without radiotherapy, and two patients did not receive any treatment. Eleven patients had ulcers on their

keloids before surgery.

After keloid resection, dimension of wound defects was 5.5 - 9.5 cm × 9.5 - 12.5 cm, with an average dimension of 7.3 cm × 10.7 cm. The dimension of flaps was 6 - 10 cm × 20 - 34.5 cm, with an average dimension of 7.5 cm × 25.5 cm. The flaps healed smoothly without complication. Postoperative pain was minimal. Radiation therapy was delivered successfully.

The mean follow up duration was 15 months. On the last follow up visit, all the patients experienced recovery from itch, pain and ulcer. 89.4% of the patients had good outcome with no apparent scar growth, and 10.6% patients experienced partial scar growth with satisfactory outcome. There was no keloid recurrence 15 months after surgery. Typical cases were presented in Figures 2-4.

4. Discussion

Keloids are pathological scars which might cause pain, itching, ulcer, and skin infections.^[15] The incidence of keloids are affected by various local, systemic, and genetic factors.^[16] Keloids are prone to develop in Asians, especially at the sites with high tension (such as the scapular region and the chest).

Although there are multiple treatment modalities, the recurrence of chest keloids is still high.^[3] Both skin graft and flaps are viable options for chest keloid reconstruction. Although there has been report with success,^[17] skin graft is inferior to flaps for two reasons. First, the expansion capability of a skin graft is not so good compared with a flap, sometimes even causing circular keloid recurrence from the incision. Second, it is risky to deliver postoperative radiotherapy after skin graft because grafted skin has weak blood supply, which could be hampered by radiotherapy. It is reported that pretreated patients with radiotherapy before skin graft had limited successful rate.^[18] Besides, skin grafts have other disadvantages such as contour deformity, color and texture mismatch.^[19]

According to our algorithm for chest keloid management, if the diameter of the chest keloid is within 3-10cm, resection and internal mammary artery perforator (IMAP) flap or local flaps should be performed.^[5] With the high tension in the chest, the choice of local flaps is limited. Tissue expander, keystone flap, and internal mammary artery perforator flap can be chosen.

Insertion of a tissue expander allows for an increase in skin island dimensions and assists in donor site closure, resulting in the shortest incision line after surgery compared with other local flaps. Although tissue expanders are commonly inserted into the chest wall for breast reconstruction, it requires two stage operations with interval of several months, which is inconvenient for the patients. In addition, the patients with ulcer/infection on the keloids are not suitable for tissue expanders insertion. Tissue expander could be reserved for the patients who expect the shortest incision scar, have enough time, and do not have ulcer or infections on their keloids.

Internal mammary artery perforator pedicled propeller (IMAP) flap is another feasible option for chest keloid reconstruction.^[20] With different angle of flap rotation, IMAP flaps can reconstruct many chest wall keloids. Bilateral IMAP flaps could also be harvested with bilateral perforators to cover larger defects. However, as a perforator pedicled propeller flap, the dissection of IMAP flap requires dissection with surgical loupes, which is technically demanding. The successful rate of a perforator flap is around 95%, with complications such as wound dehiscence, infection, and flap necrosis.^[21] Because of the postoperative radiation therapy, those complications will lead to wound healing problems which take months to recovery.

As a multiperforator advancement flap, the keystone perforator island flap (KPIF, also called keystone flap) was reported in 2003 by Behan.^[8] The shape of the flap is representative of the architectural keystone in Roman arches. Keystone flaps are classically divided into four types. Later, there have been many modifications, such as partial undermining,^[22] a fortune cookie variant,^[7] maintaining a skin bridge,^[22] or folding of the flap into an “omega”.^[23]

In this case series, the classic type IIA keystone flap was used. It is ideal for chest keloid reconstruction because the flap could distribute tension evenly around the entire incision line. Previous study has demonstrated that the levels of post-flap tension at both the defect and donor sites were significantly decreased compared with the level of pre-flap tension at the site of the defect, which indicated that the keystone flap had certainly reduced wound tension.^[24] Furthermore, it is simple to design, with a high successful rate, and no need for meticulous dissection under microscope. The modified keystone flap with a skin bridge will have greater tension and thus increase the possibility of keloid recurrence. For the female patients, the

incision line will be along the inframammary fold if appropriate. No preoperative examination was performed to detect the presence of perforators. We considered it unnecessary to locate the perforators in KPIF reconstruction performed on the chest because there are plenty of perforators and vascular connections from the internal mammary artery, superior epigastric artery, and thoracodorsal artery.^[25] There was no postoperative complication in this series. And 89.4% of the patients had good outcome. Those results indicated that the keystone flap is a good option for chest keloid reconstruction. However, when compared with free flaps, extra incision lines will be created for keystone flaps, which may increase the possibility of keloid recurrence.^[26]

Besides flap reconstruction, suture technique is also very important for tension reduction. In this series, after flap inset, tension reduction sutures were used.^[14] To avoid suture marks, continuous subcuticular suture was performed for skin closure.^[20]

It has been recognized that combination therapy with surgery and adjuvant radiotherapy is safe and most effective for management of keloids.^[4] In our series, two sessions of radiation were delivered. However, it has been demonstrated that a single dose of external radiation had low recurrence rate.^[27] Furthermore, it has been demonstrated that the recurrence rate of brachytherapy is lower than that of external radiation.^[28] We can optimize the radiation therapy regimen, especially compared the safety and efficacy of two-fraction dose with external radiation, single-fraction dose with external radiation, and brachytherapy in the future.

Besides surgery and radiotherapy, other effective modalities, such as silicone gel sheeting^[29] and compression therapy^[30] were also used postoperatively to prevent keloid recurrence. This combination could be called tetratherapy (surgery, radiotherapy, silicone gel sheeting, and compression therapy), which is more effective and should be advocated for keloid management.

However, this is a retrospective observational analysis with a limited case number. To demonstrate the efficacy of keystone flaps and other treatment options for chest keloids, a prospective randomized controlled study with more patients should be conducted.

In conclusion, keystone-designed perforator island flap is an effective and reliable method for reconstruction following chest keloid resection.

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Figure 1. Illustrations demonstrating the design of a keystone island perforator flap.

Figure 2. (a) A lower anterior chest keloid on a 46-year-old lady. (b) A defect of 6.5cm × 9.5 cm after keloid resection. (c) Flap design. The short limbs were along the inframammary fold to hide

the incision. (d) Postoperative view at 15 months.

Figure 3. (a) There were three keloids on the lateral chest of a 62-year-old lady. (b) A defect of 7 cm × 11 cm after keloids resection. A keystone flap was designed with width of 7 cm. (c) Initial closure of the wound with the keystone flap. (d) Postoperative view at 15 months.

Figure 4. (a) A upper anterior chest keloid on a 56-year-old lady. Note there is an ulcer on the keloid (black arrowhead). (b) A defect of 5.5 cm × 10 cm after keloids resection. (c) Postoperative view at 15 months.

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