The Croissant like Keystone Perforator Island Flap (CKPIF) and the Bridge Principle in Medial Canthus Reconstruction: An Update and Literature Review

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Abstract

Introduction: Medial canthus is a common area of skin cancer appearance. Its defects are considered as a challenging reconstructive task. The modified croissant-like version of KPIF (CKPIF) along with the bridge principle, which consists of the indirect transfer of the flap to the defect site through a muscular "bridge", were introduced by authors to resolve the inner convexity related problems of this area. Since then the initial series have been enriched by new cases, a longer follow up and a more important gained experience. Authors attempted to report on it realizing at the same time a literature review.

Materials and Methods: During a 27 month-period a series of patients presenting soft tissue medial canthal defects of various dimensions, secondary to tumor extirpation, sustained reconstruction with a CKPIF dissected with the bridge principle.

Results: A total of 27 patients were treated with this new technique. Their mean age was 75.15 years. The mean size of the defect was 2.12 cm X 1.52 cm. A predilection of the left side was observed (19/27 of cases or 70.37%). All flaps survived without any sign of venous congestion. A transient epiphora presented in four patients (4/27 or 14.8%), which was subsided two months later, and a minor wound dehiscence in one (1/27 or 3.7%).

Conclusion: Initial observations showed that CKPIF based on the bridge principle is a promising, technique. This larger cohort demonstrated that first impressions were correct, offering a reliable tool in medial canthus reconstruction.

Introduction

Medial canthus is aparticle area in the close vicinity of important apparatus, the eyelids, and part of the lateral nasal surface. It is commonly affected by non-melanoma skin cancer [1] as a result of a chronic sun exposure. His minimal skin laxity often renders primary closure [2] almost impossible raising the bar of difficulty to every reconstructive attempt. Subsequently, its reconstruction remains one of the most challenging facial feature tasks.

The introduction of CKPIF along with the bridge principle, the indirect transfer of the skin island of the flap to the defect site trough a muscular "bridge" (here the procerus), has proven its efficiency as an additional reconstructive tool in the medial canthal area [3]. Further experience allowed to standardize better the surgical technique increasing the cases in our series.

Other reconstructive options embracing the basic principle of "replacing missing tissue with like tissue" vary in terms of increasing complexity from the "laissez faire technique" to numerous local or regional flaps [4-18].

The aim was to share our updating experience with CKPIF, based mostly on our previous work with KPIF in other areas [19,20], and bridge principle utilization in medial canthus reconstruction realizing at the same time a literature review of the offered reconstructive options.

Materials and Methods

Study Population

From November 2016 to February 2019 a total of 27 adult patients...
suffering from medial canthal soft tissue defects, secondary to tumor extirpation, sustained reconstruction with a CKPIF using the bridge principle. No adolescents or younger aged patients have been included in the study. The Institutional ethical committee approved the study protocol. An informed consent was signed by all patients prior to every surgical procedure.

**Anatomy**

a. **Anatomical Borders [22]**

The medial canthal area, which corresponds to periorbital zone III [23, 24], involves the upper part of the nasal sidewalls, the medial canthal tendon along with the inner aspects of both the upper and lower eyelids including the lacrimal drainage system (puncta and canaliculi).

b. **Muscular Anatomy [21, 22-31]**

The procerus is a small muscle overlying the nasal bone and fusing at the same time with neighboring muscles. It disposes superficial and deep layers. The superficial layer, consisting of a middle and two lateral parts, arise from the aponeurosis of the transverse part of the nasalis (the middle part), the transverse part of the nasalis and the alar skin (the lateral parts). The deep layer originates from the nasal bone at the level of medial palpebral ligament. All these fibers converge each other and intermingle with the frontalis. Thus, the procerus extends from the transverse part of the nasalis up to the frontalis, “bridging” a large area between the glabella and the nasal dorsum. Subsequently, it connects the ocular and nasal movements.

c. **Vascular Anatomy [32, 33]**

The main blood supply of the medial canthal area is ensured by four arteries: a) the angular artery, b) the dorsal nasal artery, c) the supratrochlear artery, and d) the medial palpebral artery. Various anastomotic patterns between them contribute in the formation of a robust vascular network supplying numerous flaps.

**Surgical Technique**

As it was already described [3] we proceeded always into three steps following tumor extirpation, [Figure 1a-c]. In the first step a subdermal dissection was performed releasing completely the entire length of the skin island of the flap from its surrounding skin, [Figure 1d]. In the second step a submuscular dissection followed. The procerus was recognized and released from the underlying nasal periosteum as needed, preserving its integrity (the origin and insertion sites), [Figure 1e]. Consequently, the CKPIF enabled to reach indirectly the defect area, through the fibromuscular bridge (the procerus and nasal SMAS), according to bridge principle. Finally, flap inseting completed the entire procedure (the third step), [Figure 1f]. The main point is the placement of anchoring sutures onto the periosteum (one of them to the medial canthal tendon), to resolve all the concavity related problems raised by the medial canthal area and to offer an as much natural appearance of the reconstructed area, [Figures 1g,h].

All the above described procedure was performed by a combination of nerve block, according to Stanway and Salmon’s [34] technique, and local anesthesia (lidocaine 1% with 1: 100,000 epinephrine).
Results

All demographic details of our series are depicted in Table 1.

During a 27-month period a total of 27 adult patients sustained reconstruction for medial canthal defects of various dimensions with a CKPIF using the bridge principle. Their median age was 75.15 years (range from 45 to 92 years). Most of the patients were male (16/27 or 59.26%). The left side was affected in the vast majority of the cases (19/27 or 70.37%). Interestingly, the primary lesion affected the medial canthus in only 12 patients (12/27 or 44.44%), while in the remaining 15 (15/27 or 55.56%) it extended to neighbor anatomic areas (e.g. lower eyelid, upper eyelid, nasal lateral surface, dorsum of the nose).

The primary defect dimensions ranged from 1.0 cm (length) X 0.5 cm (width) to 3.0 cm (length) to 2.2 cm (width) with a mean of 2.12 cm X 1.52 cm. Most of them (17/27 or 63%) sustained reconstruction with the dissection of a single flap (CKPIF) with mean dimension 3.3cm X 1.3cm, using the bridge principle for a 1.7 cm X 1.3 cm mean defect.

In the remaining cases (10/27 or 37%) a second flap was used (a V-Y nasolabial flap in 9/10 of them and a V-Y Trippier flap in one, to complete the reconstruction, [Figures 2a-d]. The mean dimension of the utilized CKPIF was 4.46 cm X 1.88 cm for a mean defect of 2.84 cm X 1.88 cm.

All flaps survived without any sign of venous return related problem and the flap color remained identical since the immediate postoperative period. A minor wound dehiscence was noted in one patient (1/27 or 3.7%) and a transient epiphora in four patients (4/27 or 14.8%), which was subsided two months later. The mean follow-up was 19.56 months (range 2-30 months).

The overall patients’ satisfaction was good as the integration of the flaps evolved during the time and epiphora if present subsided. However, it was not quantified. Our aim is to perform another study focused on it with a larger cohort.

Discussion

Medial canthal area borders with various anatomic structures (e.g. medial canthal tendon, upper and lower eyelids, nose, nasolacrimal apparatus), disposing tissues of different qualities and an inner concavity. Moreover, every reconstructive attempt should focus not only on inconspicuous scar, good color and texture matching from a cosmetic aspect but also on normal tridimensional relief preservation regarding eyelid symmetry, function and vision.

Senior authors as it was thoroughly described in their initial publication [3] introduced a croissant-like KPIF (Keystone Perforator Island Flap) or CKPIF, which offered an additional length, compared to the traditional KPIF, allowing the complete filling of defects with a mean dimension of 2.12 cm (length) X 1.52 cm (width). Larger defects (mean dimension of 2.84cm X 1.88 cm) required an additional flap (a nasolabial flap in most of the cases) to complete the reconstructive effort, [Figure 2].

The bridge principle offered a new dissecting “paradigm”. According to it the flap indirectly moves through a muscular bridge, without any undermining of its skin island undersurface, to cover a defect. In the medial canthus area procerus and the nasal SMAS form this fibromuscular bridge. Preserving the integrity of its origin and insertion is the key point of the dissection. Moreover, the rich network of perforators is preserved ensuring a robust blood supply and an
Table 1: Dynamic of percentage ration of collagens of I and III types in skin and SFCT

<table>
<thead>
<tr>
<th>Number of patients</th>
<th>Sex</th>
<th>Age</th>
<th>Follow up (months)</th>
<th>Location</th>
<th>Dimensions of lesion (cm)</th>
<th>Flap dimension (cm)</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>86</td>
<td>31</td>
<td>MC (R)</td>
<td>2.2X1.3</td>
<td>4.2X1.3</td>
<td>EPIPHORA</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>48</td>
<td>31</td>
<td>MC (L)</td>
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<td>2.8X05</td>
<td>NONE</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>85</td>
<td>29</td>
<td>MC (L)</td>
<td>1.3X1.5</td>
<td>2.5X1.5</td>
<td>NONE</td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>71</td>
<td>29</td>
<td>MC (R)</td>
<td>1.1X1.2</td>
<td>2.1X1.2</td>
<td>NONE</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>77</td>
<td>30</td>
<td>MC (L)+ Nasal sidewall (L)</td>
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<td>4.0X1.5</td>
<td>NONE</td>
</tr>
<tr>
<td>6</td>
<td>F</td>
<td>64</td>
<td>20</td>
<td>MC (L)+ Nasal sidewall (L)</td>
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<td>3.5X1.2</td>
<td>NONE</td>
</tr>
<tr>
<td>7</td>
<td>F</td>
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<td>4.1X1.5</td>
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<td>M</td>
<td>86</td>
<td>25</td>
<td>MC (L)</td>
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<td>3.8X1.5</td>
<td>NONE</td>
</tr>
<tr>
<td>9</td>
<td>M</td>
<td>83</td>
<td>24</td>
<td>MC (L)</td>
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<td>3.0X1.4</td>
<td>EPIPHORA</td>
</tr>
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<td>10</td>
<td>F</td>
<td>94</td>
<td>23</td>
<td>MC (L)+ Nasal sidewall (L)</td>
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<td>3.8X2.0</td>
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</tr>
<tr>
<td>11</td>
<td>F</td>
<td>84</td>
<td>24</td>
<td>MC (R)</td>
<td>2.0X1.2</td>
<td>3.8X1.2</td>
<td>EPIPHORA</td>
</tr>
<tr>
<td>12</td>
<td>M</td>
<td>85</td>
<td>18</td>
<td>MC (L)+ Lower eyelid (L)</td>
<td>1.5X1.5</td>
<td>3.5X1.5</td>
<td>NONE</td>
</tr>
<tr>
<td>13</td>
<td>M</td>
<td>80</td>
<td>25</td>
<td>MC (L)+ Nasal sidewall (L)</td>
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<td>4.0X1.5</td>
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</tr>
<tr>
<td>14</td>
<td>M</td>
<td>86</td>
<td>11</td>
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<td>2.5X1.0</td>
<td>NONE</td>
</tr>
<tr>
<td>15</td>
<td>F</td>
<td>46</td>
<td>4</td>
<td>MC (R)</td>
<td>1.8X1.0</td>
<td>2.5X1.0</td>
<td>NONE</td>
</tr>
<tr>
<td>16</td>
<td>M</td>
<td>64</td>
<td>2</td>
<td>MC (R)</td>
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<td>2.5X1.3</td>
<td>NONE</td>
</tr>
<tr>
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<td>M</td>
<td>55</td>
<td>3</td>
<td>MC (L)</td>
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<td>3.5X1.3</td>
<td>NONE</td>
</tr>
<tr>
<td>18*</td>
<td>M</td>
<td>81</td>
<td>29</td>
<td>MC (L)+ Upper eyelid (L)</td>
<td>3.0X2.1</td>
<td>4.8X2.1</td>
<td>NONE</td>
</tr>
<tr>
<td>19*</td>
<td>M</td>
<td>55</td>
<td>29</td>
<td>MC (L)+ Lower eyelid (L)</td>
<td>2.8X1.4</td>
<td>4.2X1.4</td>
<td>NONE</td>
</tr>
<tr>
<td>20*</td>
<td>M</td>
<td>83</td>
<td>21</td>
<td>MC (L)+ Nasal sidewall (L)</td>
<td>2.5X1.7</td>
<td>3.8X1.7</td>
<td>NONE</td>
</tr>
<tr>
<td>21*</td>
<td>M</td>
<td>74</td>
<td>21</td>
<td>MC (L)+ Dorsum (L)</td>
<td>3.0X2.5</td>
<td>4.5X2.5</td>
<td>EPIPHORA</td>
</tr>
<tr>
<td>22*</td>
<td>M</td>
<td>87</td>
<td>24</td>
<td>MC (R)+ Nasal sidewall (R)</td>
<td>3.0X2.0</td>
<td>5.8X2.0</td>
<td>NONE</td>
</tr>
<tr>
<td>23*</td>
<td>M</td>
<td>80</td>
<td>16</td>
<td>MC (L)+ More parietal</td>
<td>2.1X1.8</td>
<td>4.1X1.8</td>
<td>NONE</td>
</tr>
<tr>
<td>24*</td>
<td>F</td>
<td>90</td>
<td>16</td>
<td>MC (L)+ Lower eyelid (L)+ Face (L)</td>
<td>3.5X2.1</td>
<td>5.8X2.1</td>
<td>NONE</td>
</tr>
<tr>
<td>25*</td>
<td>F</td>
<td>88</td>
<td>13</td>
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<td>5.5X2.2</td>
<td>NONE</td>
</tr>
<tr>
<td>26*</td>
<td>F</td>
<td>71</td>
<td>4</td>
<td>MC (R)+ Lower Eyelid (L)</td>
<td>3.0X1.5</td>
<td>3.1X1.5</td>
<td>NONE</td>
</tr>
<tr>
<td>27*</td>
<td>M</td>
<td>84</td>
<td>4</td>
<td>MC (L)+ Upper Eyelid (L)</td>
<td>2.5X1.5</td>
<td>3.0X1.5</td>
<td>Minor dehiscence</td>
</tr>
</tbody>
</table>

MC, Medial Canthus;

*Patients 18-27: an additional flap was required to close the defect. In most of them (patients 18-26) a V-Y nasolabial flap was used, while in the remaining one (patient 27) a V-Y Tripier flap was needed.
A 84-year old male patient presented with a 1.5X1.3 cm lesion on the medial left canthus. A 3.0X1.5 cm CKPIF along with a V-Y Tripier flap considered for his reconstruction.

**Figure 2b:** Immediate postoperative result

Excellent venous outflow of the flap. Subsequently, no sign of venous congestion was observed during the intra or the postoperative period.

Placement of anchoring sutures is an obligatory step of the surgical procedure that allows to overcome the concavity related problems of the medial canthal area and provides a better flap integration during insetting. Thus, a better aesthetic outcome is ensured.

**Other series**

Fox and Beard [36] in 1964 initiated the laissez faire method in medial canthal reconstruction reporting excellent aesthetic outcomes. The key point according to authors is the utilization of full thickness sutures, through the conjunctival ends of the cut eyelids, to create a medial canthus substitute.

Skin grafting could be an alternative method in medial canthal region reconstruction. Theoretically, either a STSG [37, 38] or FTSG [37, 39, 40] can be effective. However, as graft contracture is thickness related and occurs more frequently in thinner grafts, STSG are often precluded, unless the defect is very large or other option does not exist. Moreover, it can be used as monitoring “window” for high risk recurrent lesions [37]. On the other hand, FTSGs offer a better outcome, which is long standing [37] to appear, with persistent differences in skin texture and color. Subsequently, patient should be always counseled preoperatively for the graft’s cosmetic appearance problems.

Flaps remain the most technical and interesting reconstructive option. The rhomboid flap [14, 41] is a “classic” and versatile solution well adapted to the medial canthal particularity. Secondary defect is closed by neighbor tissue undermining. Ng et al. [14] in a series of 27 patients report on excellent cosmetic outcome. Minor webbing was noted in only 2 patients.

Custer [2] proposed a transnasal flap, which could be considered as a triangular version of the rhomboid flap, with good aesthetic outcome.

Bilobed flap, which initially was described by Esser [42], provides a valuable solution at this site. Successful result depends on its design [12, 17, 43]. Dog ear, pincushioning, and scar line complications are the main drawbacks of this technique [44].

Forehead and glabellar area remain the “gold standard” donor sites providing flaps for medial canthus reconstruction. However, the idea for their utilization is not new. It dates to nineteenth century [7]. McCord and Wesley described first the glabellar flap [45], which in its simplest form is a “V-Y” flap, whose “Y” limb provides adequate tissue for transposition into the medial canthus. Eyebrow narrowing following closure is a common problem. Meadows and Manners [11], in 2003, had proposed the utilization of a skin graft obtained from the trimmed tip of the glabellar flap to fill the secondary defect in an effort to correct it. Moreover, as mobilized skin is relatively thick a bulky deformity can ensue, necessitating secondary debulking procedures.

Emsen and Benlier [9] in a series of 8 patients introduced the super thinned inferior pedicled glabellar flap, which disposed a rectangular design and was completely “voided” from its thick elements (subcutaneous fat and musculature). They reported satisfactory outcomes without any sign of necrosis and no additional procedure.

Turgut et al. [46] modified more the glabellar flap proposing the “flap in flap” technique. According to them a diagonal line was designed in the inverted V of the flap dividing it into two segments.
This one closer to the defect was transposed to fill in it, while the other covered the secondary defect. Careful dissection is of paramount importance to prevent flaps’ necrosis.

Another modification of the glabellar flap was proposed by Bertelmann et al. [47] who tunneled the flap to the defect area in an effort to avoid nasal dorsum bulging. In these series of 10 patients’ outcomes were satisfactory. However, a second stage was required to resect the pedicle 4 weeks later.

For more complex defects with additional involvement of the upper or lower eyelids a single traditional glabellar flap is not suitable to resolve the problem. A more subtle strategy is required. Chao et al. [48] reported on a combination of an orbicularis oculi myocutaneous advancement flap with a glabellar flap with two limbs providing satisfactory results in their 12 patients’ series.

For larger defects Onishi et al. [15] described the utilization of a rectangular glabellar flap to close the medial canthal lesion combined with a Rintala flap for the donor site. Similarly, for such large defects Panizzo et al. [49], in a small series of 6 patients, introduced the extended bilobed glabellar-palpebral flap. All flaps survived. However, a transient postoperative venous congestion was noted in 4 patients. Moreover, Lykoudis et al. [50] proposed the “pickaxe” double flap, in their series of 17 patients, which combined a glabellar with a nasolabial flap. These flaps along with the medial canthal defect formed a kind of virtual “pickaxe”. The glabellar flap restored the upper part of the defect while the nasolabial flap the lower. Postoperative follow up period was uneventful.

A different approach was proposed by Seyhan [51] who described the figure of eight radix nasii flap (with a mean dimension of up 25mm). Anatomically, is based on the anastomosis of angular artery with dorsal nasal artery. The flap is extended from the medial canthal defect to the contralateral side, while the pedicle is placed near the defect. Dissection proceeded from distal to proximal into supramuscular plane. All flaps survived without reported complications, while the donor area was closed primarily. Satisfactory outcomes have been obtained in these series of 8 patients.

Baltu and colleagues [52] went a step further their reconstructive approach for this area. They described the central artery propeller perforator flap as an alternative for medial canthal and nasal defects. Dissection was more demanding. A total of 22 patients, perhaps one of the largest series in the literature, sustained reconstruction with this technique. Venous congestion was noticed in 5 patients with partial flap necrosis in two of them.

General Considerations

Going through the tremendous work of the aforementioned investigators it can be remarked that most of them share a common point: the improvement and refinement of a valuable but already existing technique. The combination of a new principle (bridge principle) based on the local anatomy, with the modification of a relatively recent but well-established flap (CKPIF), lead authors to introduce a new reconstructive tool. The skin island of the flap is transferred, following dissection, to the defect site not directly but indirectly through a muscular bridge.

Our further experience based on a larger series (27 vs 15 patients) and on a longer follow-up (19.56 vs 6 months) demonstrated clearly that our initial observations were correct. The technique is safe and easy to perform even for a novice Plastic Surgeon. It includes two releases of the skin island of the flap, one around it (supramuscular) and a second below it (submuscular). There is a critical defect with a mean dimension of 2.0 cm X 1.5 cm that allows reconstruction by a single flap (CKPIF). Beyond it an additional flap is needed.

Conclusion

The concept of flap dissection with release of an anatomically identifiable pedicle (fixed or perforator), and direct insetting to the defect area has changed. The bridge principle offered a new paradigm, that of the indirect flap transfer.

Initial observations showed that CKPIF based on the bridge principle is a promising, safe, versatile and replicable technique. This larger cohort (27 patients vs 15 patients) with a much longer follow up (1956 months vs. 6 months), which is one of the larger in the existing literature, demonstrated that first impressions were correct, offering a new tool in medial canthus reconstruction and perhaps opening the way for further applications in other anatomical sites.

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