A 20-Year Experience with Tissue Expansion for Large Cervical Fascial Defects: An Algorithm Based on Different Clinical Flap Designs

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Facial Plast Surg

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Abstract

Over the past 20 years, we have designed various types of expanded cervical flaps for large facial defects and achieved excellent tissue matching. This study was performed to propose a treatment strategy for flap selection for the reconstruction of different facial units. The authors retrospectively reviewed the application of cervical expanded flaps for facial rehabilitation in our department between January 2003 and January 2023. The study included 122 patients with unilateral (62.3%) and bilateral (37.7%) facial deformities ranging from the zygomatic arch to the chin. The median area of the tissue defect was $15.2 \times 8.5 \text{ cm}^2$ (ranging from $6 \times 4 \text{ cm}^2$ to $27 \times 12 \text{ cm}^2$). The expansion period ranged from 61 to 175 days (mean: 86.5 days). Maximum and minimum sizes of pre-expanded cervical flaps were $30 \times 13 \text{ cm}^2$ to $7 \times 5 \text{ cm}^2$. All the flaps could be summarized into type 1, an advanced expanded cervical flap; type 2, a wing-shaped expanded cervical flap with overlapping tissue expansion; and type 3, an expanded single-lobed transposition flap rotated based on the anterior neck. Cervical flaps reliably meet the reconstructive requirements for different facial units, especially for large cutaneous defects in the clinic. The selection of these flaps can be planned preoperatively according to the location and size of the defect or lesion.

Sustaining a massive deformity, such as a scar or nevi on the face, is one of the most devastating injuries in terms of social interaction and psychological health.1 The facial surface area possesses unique characteristics, and its smooth and slightly convex contours often pose significant challenges in the reconstruction of large defects. Li et al2 proposed that the most important principle, “MLT,” for facial reconstruction involves restoring the matched skin color and texture to obtain a normal face appearance, covering a massive lesion, and highlighting the expression of emotion through the use of thin soft tissue. The ideal substitute must provide a matching texture, tenacity, and thin subcutaneous fat.

Aesthetic reconstruction is maximized by “like-for-like” coverage rather than the transfer of distant tissues with a poor texture or color match.3 Cervical flaps often act as workhorse flaps during reconstruction for facial defects. The neck area, which is adjacent to the face, pliable, well matched, and has reliable blood supply from different arteries, is a source of various types of cervical flaps for reconstructing facial units. Soft-expansion techniques often generate additional tissue for the defect area, improving vascularity and allowing for primary donor site closure,4,5 which is considered a milestone in plastic surgery. For the aesthetic treatment of massive deformities, improvements in flap size and thickness can be achieved with a cervical flap and tissue expansion technology.

Many expanded cervical flaps, such as prefabricated flaps, super-thin flaps, perforator flaps, and other random cervical flaps (advancement, rotation, or interposition), have been used,5–13 which have similar color, texture, and thickness to...
the face and are large enough to cover lesions, providing good functional and aesthetic outcomes for patients with extensive facial subcutaneous deformities and undamaged muscles and deep structures. However, systematic evaluations focusing on different types of expanded cervical flaps in facial reconstruction remain limited. Since 2003, we have harvested different types of cervical expanded flaps for cutaneous facial defect reconstruction. Various surgical design approaches are available for cervical flaps, allowing for the selection of different surgical strategies based on the location and size of facial defects. Here, we classify patterns of repair surgeries and describe a treatment algorithm for achieving good functional outcomes.

**Patients and Methods**

We retrospectively reviewed all patients treated with expanded cervical flaps to repair facial defects between January 2003 and January 2023 in our department of the Plastic Surgery Hospital, Chinese Academy of Medical Sciences. The parameters included the location and size of the facial defect, flap expansion and size, width of the pedicle, and the flap transfer method. The preoperative and postoperative images of patients, surgical procedures, and follow-up data were collected for further analysis of the reconstruction outcomes. The study protocol was approved by the institutional review board of the Plastic Surgery Hospital and was in accordance with the Declaration of Helsinki.

According to previous articles, the face can be artificially divided into five subunits: the forehead, orbit, nose, cheek, and perioral area (lips and chin). The cheek area can be further divided into four subunits: infraorbital, zygomatic, preauricular (or lateral cheek), and buccal. Three types of expanded cervical flaps were adopted according to the location and size of the facial deformities.

**Placement of the Expanders**

An artificial pocket to implant the expander was created in the healthy skin of the neck, which was close to the lesion, after general anesthesia. The dissection plane was created between the subdermal tissue and the platysma until it met the marked outline of the flap pedicle region. The flap was elevated carefully to prevent damage to the external jugular vein and the anterior superficial jugular vein in the supraplatysmal layer. We normally implant 200- to 400-ML expanders for children and 600- to 800-ML expanders for adults. Two weeks later, tissue expander inflation commenced with 0.9% NaCl injection once a week. The volume of normal saline injected each time was 10 to 15% of the rated total for the expander. When the expansion period was completed, reconstruction was postponed for 2 weeks to prevent the expanded flap from contracture.

**Transfer Expanded Cervical Flap**

Measurements of the lesion’s size must account for facial convexities and concavities. Based on different facial defects, we summarized the following techniques: type 1—the expanded cervical flap was advanced cephalically based on the anterior neck; type 2—the wing-shaped cervical flap with overlapping tissue expansion was rotated cephalically with the pivots in both sides of the neck with the pedicle on the anterior neck; and type 3—the expanded single-lobed transposition flap was rotated based on the anterior neck. The adaptation for these three techniques will be discussed later. It is critical that the flap and its pedicle are oriented in a geometrically favorable fashion and not kinked to avoid jeopardizing the flap’s blood supply.

**Results**

We used expanded cervical skin flaps to resurface facial lesions in 122 patients (Table 1). Among these patients, 36 (19 males and 17 females) were treated with wing-shaped cervical flaps with overlapping tissue expansion pedicled on the anterior neck, 47 (21 males and 26 females) with expanded single-lobed transposition flaps rotated pedicled on the anterior neck, and 39 (19 males and 20 females) received advanced expanded cervical flaps. The surgical defects spanned areas of 6 \( \times \) 4 to 27 \( \times \) 12 cm\(^2\). The maximum and minimum sizes of the pre-expanded cervical flaps were 30 \( \times \) 13 and 7 \( \times \) 5 cm\(^2\). All wounds at the donor sites were closed by direct suturing. The expansion period ranged from 67 to 175 days (mean: 86.5 days), and the details of the expansion are listed in Table 2.

**Type 1**

Lower face deformities involving the perioral region, chin, and superior mandible region unilaterally or bilaterally could be repaired by the expanded cervical flap, which was advanced cephalically upward of the lesion. The Z-plasty technique was performed in the lateral region to prolong the cephalic advancement of the expanded flap (Fig. 1).

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**Table 1 Patients reconstructed with cervical flaps**

<table>
<thead>
<tr>
<th>No. of patient</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>19.2</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>10–36</td>
<td></td>
</tr>
<tr>
<td>Lesion sites</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bilateral</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>Unilateral</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td>Causes of these defects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postburn scars</td>
<td>51</td>
<td></td>
</tr>
<tr>
<td>Melanocytic nevus</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Hemangiomas</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Pigmented skin grafts</td>
<td>21</td>
<td></td>
</tr>
</tbody>
</table>
Table 2  Summary of the complications associated with the three types of flaps

<table>
<thead>
<tr>
<th>Type</th>
<th>Expander</th>
<th>Shape</th>
<th>Ultimate volume (mL), mean (range)</th>
<th>Expansion</th>
<th>Expanded flap</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>200–800</td>
<td>Rectangular</td>
<td>640 (180–840)</td>
<td>Once weekly</td>
<td>8 × 5–16 × 6</td>
</tr>
<tr>
<td>2</td>
<td>400–600*</td>
<td>Rectangular</td>
<td>970 (600–1,100)*</td>
<td>Once weekly</td>
<td>12 × 8–30 × 13</td>
</tr>
<tr>
<td>3</td>
<td>300–600</td>
<td>Rectangular</td>
<td>480 (350–810)</td>
<td>Once weekly</td>
<td>6 × 4–12 × 5</td>
</tr>
</tbody>
</table>

*In type 2 methodology, two equally sized expanders are positioned within the pocket, symbolizing the volume of each individual expander.

Fig. 1  Reconstruction of the bilateral cheek by the expanded cervical flap advanced based on the anterior neck. (A) A patient with a postburn scar measuring 27 cm × 9.5 cm in the perioral, cheek, and around the superior mandible, and chest regions. Two expanders measuring 600 mL were placed under the neck cutaneous tissue, and two expanders measuring 800 mL were buried in the chest. (B) A large pre-expanded cervical flap was elevated after removal of the neck expanders. The crossing arteries within the flap are clearly visible after expansion. (C) The cervical flap was advanced cephalically to reconstruct the cutaneous defect after the excision of the superficial scar. (D) The patient indicated that the outcome was satisfactory during the 18-month follow-up.

Type 2
Bilateral middle and lower face deformities with large sizes, including the perioral, zygomatic, and buccal regions, could be repaired with the “wing-shaped” cervical flap rotated cephalically based on the anterior neck with overlapping tissue expansion in the midline. In these situations, more tissue is needed to cover large defects and ensure sufficient soft tissue along the longitudinal axes on the midline with the aim of guaranteeing a normal neck shape and a normal range of cervical extension, rotation, and lateral flexion. To overcome this, we placed the lower thirds of the two rectangular expanders, overlapping each other at the midline of the neck in the pocket to gain more length along the midline (Fig. 2A). In the second stage, additional incisions were designed to create two wing-shaped flaps, which were used as two rotation flaps to cover the defects of the midface on the left and right sides, with two rotation pivots in the midportion neck (Figs. 2B and 3). The flap was rotated (45–70 degrees) and advanced to the lower-middle part of the face. The pedicles were kept 10 to 13 cm in width to ensure sufficient blood supply for this random flap. The anchor position of the flap was on the horizontal line of the thyroid cartilage to maintain a normal cervicomental angle.

Type 3
Unilateral lateral face deformities involving the preauricular and buccal regions could be reconstructed with expanded single-lobed transposition cervical flaps rotated based on the anterior neck (Fig. 4). The flap was transferred into the recipient site by pivoting on a base with movement over an area of normal adjacent skin with angles of rotation approaching 45 to 60 degrees. The surgical scar was well hidden along the preauricular crease or earlobe, maximally preserving the aesthetic appearance, and with the aim of minimizing the rotation angle. Carried with the ipsilateral mastoid region skin to enlarge the length of the flap, which can be especially useful for extending the high cephalad level of the cheek and helps decrease the incidence of hypertrophic and wide scars (Fig. 5).

The locations of the defects for each type of flap are summarized in Table 3. The proposed algorithm for large cutaneous defect reconstruction of the face with the various types of expanded cervical flaps is shown in Fig. 6.

During follow-up visits (range: 6 months–12 years), the transferred flaps matched well with the facial skin in terms of texture and color. Expander-related complications comprised mainly infections (5.2%), port leakage (2.34%), and hematoma (1.58%). Complications were hypertrophic scarring (17.6%), dog-ear (10.2%), wide scarring (33.5%), and epidermal necrosis in the distal part (8.5%). There was no secondary deformity, such as angular displacement, limited mouth opening, or lower eyelid ectropion. Some patients underwent different types of revision treatments, such as scar revision (31.8%), flap trimming (4.5%), surgery...
Fig. 2  (A) The lower third of two rectangular expanders were placed, overlapping each other at the midline of the neck in the dissected cavity. (B) In the second surgery, additional incisions were made to create “wing-shaped” flaps, which were used as rotation advancement flaps. The A, B, C, and D points on the expanded cervical flap were moved to positions A’, B’, C’, and D’ on the facial defect area in a one-to-one correspondence. The Z-plasty technique was performed in the lateral region to prolong the cephalic advancement of the expanded flap.

Fig. 3  Reconstruction of the bilateral middle and lower face deformities with the advanced cervical flap by overlapping tissue expansion. (A–C) A patient with a postburn scar measuring 23 × 8 cm in the chin and lower and lateral cheek regions. The scar in the perioral area limited mouth opening. In the first stage, two expanders (600 mL each) were placed, overlapping each other at the midline of the neck in the dissected cavity, and the flap was expanded for 3 months. (D–F) After removing the lesion, the expanded cervical flap was transferred to cover the defect on the face.
Table 3: Summary of the complications associated with the three types of flaps

<table>
<thead>
<tr>
<th>Type</th>
<th>Locations of the defects</th>
</tr>
</thead>
</table>
| Type 1     | Perioral \((n = 14)\)  
Partial buccal + perioral subunit \((n = 25)\) |
| Type 2     | Chin + buccal + partial zygomatic + partial lateral cheek \((n = 10)\)  
Chin + buccal + partial lateral cheek \((n = 10)\)  
Chin + buccal + partial zygomatic subunit \((n = 16)\) |
| Type 3     | Lateral cheek \((n = 20)\)  
Lateral cheek + buccal subunit \((n = 27)\) |

Note: Type 1: In this approach, the expanded cervical flap is advanced cephalically based on the anterior neck.  
Type 2: This technique involves creating a wing-shaped cervical flap with overlapping tissue expansion. The flap is then rotated cephalically using pivots positioned on both sides of the neck, while the pedicle remains situated on the anterior neck.  
Type 3: Within this category, the expanded single-lobed transposition flap is rotated based on the anterior neck.
with facial expanded flaps (7.5%), and laser scar removal (20.8%), to further improve the aesthetic contour. A total of 96 patients (78.68%) were satisfied with both the functional and aesthetic results. The cervicomental angle remained normal in all patients.

Discussion

Conventional skin grafting of the facial region is gradually being eliminated because of the mediocre aesthetic appearance due to the differing textures of the grafts, which have a “masklike” pigmented effect, and due to the poor laxity of the skin. Small to moderate lesions can be primarily closed, and if not, a Z or V-Y type of local plastic flap may be required. However, most lesions caused by burns or congenital nevi often destroy two or more subunits, often requiring substantial cutaneous tissue for repair.

Previous studies have demonstrated that forehead flaps and deltopectoral flaps combined with tissue expansion technology provide more reconstruction materials that match the facial skin regarding color, texture, and thickness. However, a hair-bearing flap does not meet the principles of plastic and reconstructive surgery. The patients need further treatment, such as a laser hair removal technique, to improve the final outcome when using the expanded forehead flap to repair the sizable facial defect. Using expanded deltopectoral flaps can simultaneously meet the requirements of sufficient nonhair tissue and “like-for-tissue” coverage, while for females, expansion of the deltopectoral region may lead to nipple and breast displacement. Considering these findings, expanded cervical flaps seem to be an ideal and suitable technique for treating sizable facial defects.

Cervical skin is close to facial skin in terms of thickness, color, and texture and is one of the most frequently used repair materials. The blood supply of cervical skin is diverse and reliable and mainly comes from the branches of the submental artery, superior thyroid artery, transverse cervical artery, inferior thyroid artery, external carotid artery, occipital artery, and subclavian artery. Wang et al proposed that the mechanism to improve pre-expanded flap survival is thought to be the “bridging effect” through prefabrication of the blood supply within the flap. During pre-expansion of the skin flap, choke anastomoses can be changed into real anastomoses and increase the caliber of adjacent communicating branches as well as neovascularization, which can improve the perfusion of the flap. This was also confirmed by microscopic observations. In summary, the application of tissue expansion techniques can not only increase the vascularization of the cervical flaps but also increase the skin surface area and achieve successful primary donor site closure, reducing the soft-tissue thickness to allow for facial expression and preservation of facial contours. Furthermore, a cutaneous flap without muscle is more suitable for repairing facial defects not only because of its proper thickness but also because it prevents secondary contracture of the flap.

We developed a strategy for selecting expanded cervical flaps in terms of deformities or lesion location and size according to our experience and a literature review. Different types of expanded cervical flaps can be used to reconstruct different facial subunits. Type 1 flap is the advancement of an expanded cervical flap based on the anterior neck, which is easy to design and manipulate for the lower face. However, when the lesion destroys most of the midface and is larger in size, redundant cervical skin along the longitudinal axes is required to guarantee the neck’s movement without restriction and prevent postoperative scar contractures. Type 2 flap could reach the zygomatic arch level, and the natural
appearance of the cervicomental angle could also be restored by sufficient tissue. Type 3 flap can be applied to reconstruct the defect on the lateral face, especially the longitudinal incision. This can help prevent distortion of the adjacent organs, especially when extending the flap to the high cephalad level of the cheek and the lower eyelid.¹⁻³

Conclusions

Unlike free flaps and skin grafts, cervical expanded flaps can be used to reconstruct sizable unilateral or bilateral facial defects from the zygomatic arch level to the chin and from the perinasal area to the preauricular area. Although patients have to bear the physical and psychological morbidity of the expansion, several operative sessions, and the possibility of complications, the use of cervical expanded flaps remains reliable and technically simple, with minimal donor site morbidity.

Conflict of interest
None declared.

References