

# Head and Neck Reconstruction in Burn Patients



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## KEYWORDS

• Thin flap • Skin pedicled flap • Skin graft • Perforator flap • Supercharging • Expanded flap

## KEY POINTS

- In head and neck reconstruction, it is crucial to sufficiently relieve the tension on the neck.
- If using a skin flap, the skin-pedicled flap releases contracture more effectively than the island flap.
- During planning, it is necessary to consider the gender of the patient gender and the timing of the reconstruction.
- It is beneficial to use a large and thin single flap, preferably one whose vasculature can be supercharged.

## INTRODUCTION

Reconstruction of burns in the head and neck area is particularly challenging because there is a high demand for both functional reconstruction that restores the complex movements of the neck and esthetic reconstruction. Local flaps are best for minor defects, especially deep burns, because their texture and color match. However, for large deep burn wounds that have led to scar contractures, it is crucial to ensure that the contractures are fully released and re-contracture will not occur. In this case, simple skin grafting or local flaps often do not yield satisfactory results.

According to data on Asians, the average skin thickness (including the epidermis and dermis) varies markedly depending on the body region.<sup>1</sup> Thus, the skin thicknesses on the cheek, chin, anterior neck, upper clavicle, and anterior chest are 1140, 860, 1410, 770, and 1440  $\mu\text{m}$ , respectively<sup>1</sup> (**Table 1**). The areas where bones are located directly under the skin (ie, the chin and upper clavicle) tend to have thin skin. This means that reconstructing these areas with a thick flap will not provide esthetic results. Rather, their contour should be carefully reproduced by either using thin flaps or thick skin grafts. However, with regard

to full-thickness skin grafts, it is difficult to reconstruct a large skin defect that runs from the jaw to the chest with them. Moreover, skin grafts in highly mobile areas such as the neck may not sufficiently prevent secondary scar contracture because they lack a fatty layer. It should be noted that there is 1 exception to this, namely, the face; although the face is highly mobile, skin grafts are the primary choice for facial defects since they often successfully reconstruct burn wounds in the peri-oral and peri-orbital areas. Thus, extensive deep burns of the neck are best reconstructed with a large thin flap, since they yield excellent results.<sup>2</sup> In this article, the author will discuss the usefulness of thin flaps for reconstructing head and particularly neck burns, since the latter are highly prone to burn scar contracture.

## INDICATION FOR RECONSTRUCTION

To identify the optimal approach to face and neck reconstruction, it is important to first classify the defects in the chin-neck-anterior chest units in terms of their size and depth<sup>3</sup> (**Box 1**). Wound depth can be broadly categorized as superficial to the platysma or deeper than the platysma; in the case of the neck, this means the wound does

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**Table 1**  
**Differences in skin thickness, as determined by cadaver study in Asian men and women**

	Male (μm)	Female (μm)
Cheek	1240	1040
Chin	890	750
Anterior neck	1560	1260
Supraclavicular	960	560
Anterior chest	1390	1490
Abdomen	1440	1230
Back	2280	1470
Inguinal	500	500
Anterior thigh	1160	1080

The data show the average skin (epidermis and dermis) thickness of Asian men and women.

or does not reach the sternocleidomastoid muscle. Wound size is categorized as linear/planar scar contractures or small/large defects and whether the contracture/defect is confined within a unit or extends into adjacent units; in the case of the neck, its units encompass the central region and the left-right regions that are bounded by the sternocleidomastoid muscle.<sup>3</sup>

Linear scar contractures or small skin defects that are confined within a neck unit can be reconstructed with Z-plasty or various local flaps. However, if the linear scar contracture extends into an adjacent unit, it is necessary to release the contracture and ensure that the 2 units are clearly separated; this prevents re-contracture.

By contrast, planar scar contractures or extensive skin defects should be reconstructed with thick

skin grafts or flaps. Depending on the case, an expander can also be used.<sup>4</sup> If the contractures or large skin defects remain within a single unit, the choice between a skin graft and flap depends on the depth of the reconstruction site. If it does not reach the platysma, a skin graft can be used. These grafts must be full thickness and their primary aim is to prevent (re)contracture and pigmentation. They can be combined with a dermal regeneration template such as Integra.<sup>5</sup> Thick skin grafts that preserve the subdermal vascular network (SVN)<sup>6</sup> can also be used but they will require reliable compression and fixation techniques.

For deep scar contractures or skin defects that reach an adjacent unit, or remain within 1 unit but reach the platysma, flaps are a good choice. It is desirable to use a large thin flap whose color and texture closely matches that of the neck.<sup>7</sup> To select the optimal flap, it is necessary to determine the range of reconstruction needed and the available donor sites.

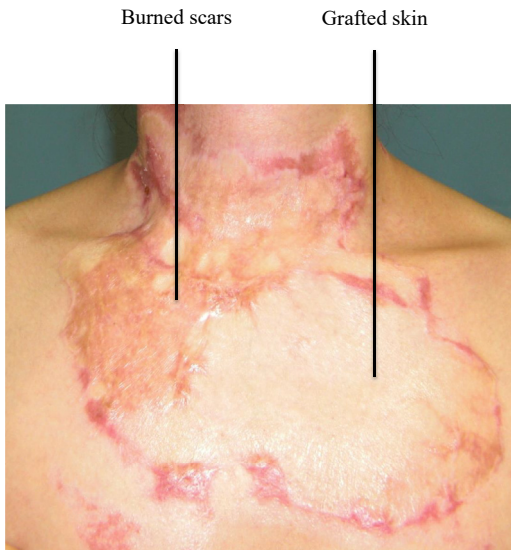
**TENSION RELEASE**

The head and neck primarily extend and flex significantly in the anteroposterior direction. This means that chin-neck-anterior chest burns frequently develop into pathologic scars such as hypertrophic scars and keloids; these are abnormal skin fibroses that arise after skin injuries, especially burns, and can lead to scar contractures. Skin tension is a major risk factor for the formation of these scars.<sup>8</sup> Thus, a key objective when reconstructing burn defects, including contractures, in chin-neck-anterior chest region is to relieve tension in the anteroposterior direction. Flaps are particularly useful for releasing or preventing contracture because flaps bearing subcutaneous tissues expand naturally after surgery; this means that they are not prone to postsurgical hypertrophic scarring or contractures. By contrast, skin grafts do not expand. This means that skin grafts are stiff and cannot release the repetitive skin tension induced by daily movements of the neck and upper limbs. As a result, skin grafts tend to generate circular scars around the grafted skin that often progress into secondary contractures (**Fig. 1**). This link between skin stiffness and contractures also explain why burn scars, which are very stiff, are prone to forming contractures on the neck (and other mobile areas).

Thus, flaps are particularly useful for reconstructing the head and neck region. Ideally, these flaps should have skin pedicles because they expand better than island flaps and therefore release contractures more effectively<sup>9</sup> (**Fig. 2**). Moreover, the postoperative extensibility of the

**Box 1**  
**Classification of preoperative face and neck scar contractures for determining reconstruction options**

- I Linear scar contracture or small skin defects confined within each unit
- II Linear scar contracture or small skin defects extending into adjacent units
- III Planar scar contracture or large skin defects confined within each unit
- IIIa Does not reach the muscle (in the neck, does not reach the sternocleidomastoid)
- IIIb Reaches the muscle (in the neck, reaches the sternocleidomastoid)
- IV Planar scar contracture or large skin defects extending into adjacent units
- V Those that cannot be classified into I–IV



**Fig. 1.** Circular scars can develop around grafted skin. Since grafted skin and the scars on the margin of the graft are stiff, the skin tension produced by body movements such as turning of the head cannot be released. This causes the margin of graft to become inflamed and generates hypertrophic scars or keloids. Since these scars themselves are very stiff, they can readily progress into contractures.

flap should be considered when determining the optimal flap design for the individual patient. If the area of reconstruction is large, large local flaps with supercharged vessels can be designed.<sup>10</sup> If adjacent skin cannot be used as a flap-donor site, free flaps should be selected. However, this is the least preferred choice because free flaps are always island flaps; thus, they will not expand effectively and may be prone to hypertrophic scarring/secondary contractures. Thus, for deep scar contractures, the order of choice should be (1) a skin-pedicled local flap/supercharged skin-pedicled flap and (2) a free flap.

### TIMING OF RECONSTRUCTION

Large burns and their resulting extensive wound-healing process provoke a prolonged systemic cytokine storm.<sup>11</sup> This may be a major risk factor for the formation of hypertrophic scars and keloids after burn. This notion is supported by recent studies that suggest these pathologic scars can be promoted by systemic factors, including hypertension, female hormones, and high levels of various cytokines and growth factors in the blood.<sup>11</sup> Consequently, it is thought that reconstructive surgery within 1 year of sustaining a burn injury, particularly with poorly extensible skin grafts or local flaps, bears a high risk of

postoperative pathologic scarring and severe contracture. This risk may be even greater in cases with conditions such as hypertension. A potential way to minimize this risk is to use as much as possible single large thin flaps for reconstruction.

### BASICS OF FLAP HARVESTING

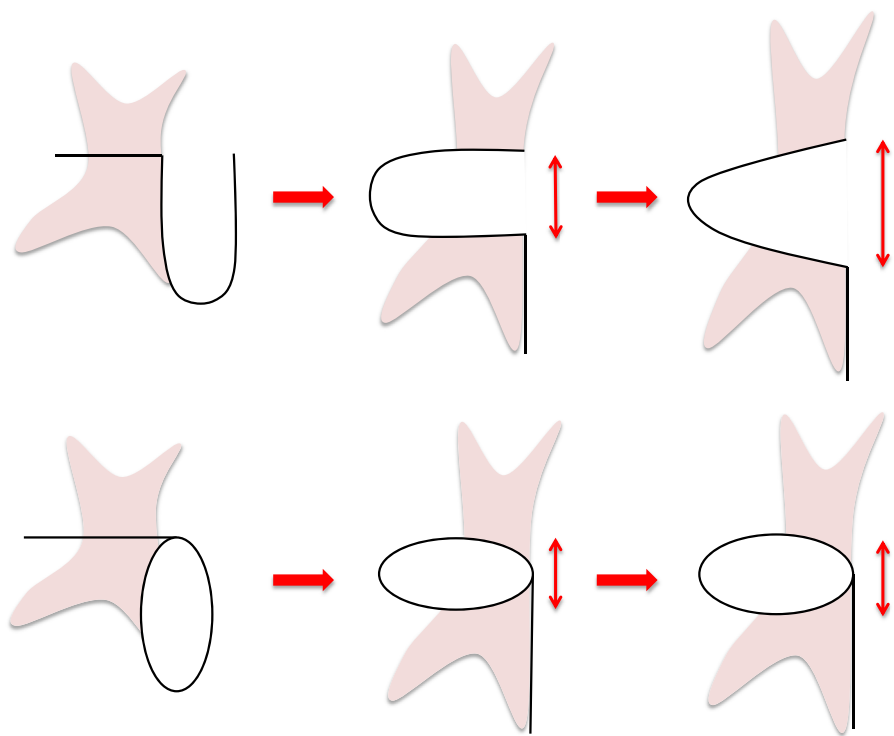
A large thin skin flap is appropriate in cases IIIb and IV in **Box 1**, namely, if the neck scar reaches the sternocleidomastoid and is also a linear scar contracture/small unit-confined or unit-crossing defect/large unit-confined defect (IIIb) or a planar scar contracture/large unit-crossing defect (IV). Depending on the situation, one should choose either a vascular-pedicled flap or a free flap that has a vascular pedicle. An expander may also be utilized. If the burn is extensive, the number of donor sites that are available will be limited. However, the author will review here the hypothetical case where all donor sites are available. A number of points regarding flap harvest should be considered.

#### *Skin Color and Texture*

The upper-clavicular and anterior-chest regions are classical cases of areas that generally have 1 donor site available that can yield skin flaps that closely match the recipient site in terms of color and texture (**Fig. 3**). In this case, the donor site is the back; even if the case involves extensive burns, the skin of the back is often preserved. However, it should be noted that in males, the back skin is slightly thicker than the neck skin. Other donor-site possibilities are the abdomen, thigh, and inguinal regions. However, in Asian people, the abdomen and thigh regions are paler than the neck while the inguinal area tends to be darker. Moreover, the abdomen and inguinal areas have a different texture than the chin and anterior neck, which makes them challenging to use for reconstruction. However, bilateral inguinal flaps have been reported to have good outcomes when used for anterior neck reconstruction.

#### *Gender Differences in Skin Thickness*

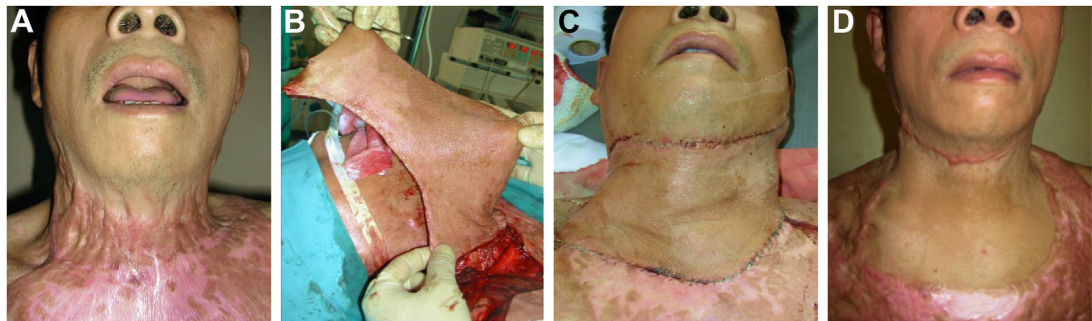
Women and men differ in the skin thickness in various areas. Specifically, in Asian men and women, the anterior neck/back skin-thickness ratio is 1:1.5 and 1:1.2, respectively (see **Table 1**). Thus, harvesting a flap from the back and transplanting it to the anterior neck is generally more suitable for women (**Fig. 4**). Conversely, the anterior neck/chest ratio is 1:0.9 for men and 1:1.2 for women. Thus, chest-to-neck transplants are more suitable for men (**Fig. 5**) but not women. This is compounded



**Fig. 2.** Skin-pedicle flaps release tension much better than island flaps. Flaps that bear a skin pedicle (*top*) release the tension on the neck-anterior chest region that is induced by body movements. They also expand over time in the predominant direction of tension after surgery, thus further relieving the tension. By contrast, island flaps (*bottom*) expand poorly because of the lack of a skin pedicle. This makes these flaps prone to forming hypertrophic scars around their margin after surgery.

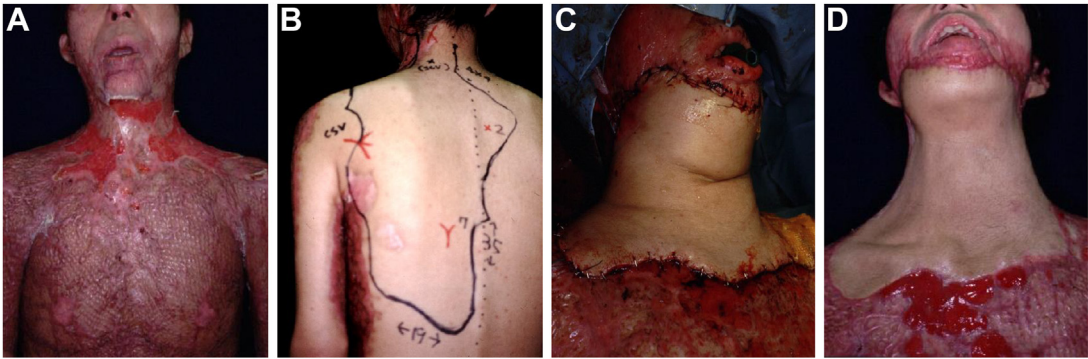
by the fact that harvesting flaps from the chest in women can result in asymmetrical breast positioning. Thus, for men, it is better to harvest from the chest, and for women, from the back. However,

since the supraclavicular area is thin in both genders (less than 1000  $\mu\text{m}$ ), flaps from this region are suitable for reconstructing the chin and anterior neck in both men and women.



**Fig. 3.** Reconstruction of neck contracture with a pedicled supraclavicular flap. A male in his 40s underwent reconstruction of his anterior-neck contracture with a 25  $\times$  15-cm supraclavicular flap. The flap was elevated as vascular-pedicled flap and survived completely. Although slight hypertrophic scars developed on the flap margin, the neck movement of the patient recovered to the point that he reported no problems in daily life. The donor site was closed by using a split-thickness skin graft. (A) Preoperative view. (B) Flap harvest. (C) Immediately after surgery. (D) One year after the operation. (With permission from the publisher: Vinh VQ, Van Anh T, Ogawa R, Hyakusoku H. Anatomical and clinical studies of the supraclavicular flap: analysis of 103 flaps used to reconstruct neck scar contractures. *Plast Reconstr Surg.* 2009 May;123(5):1471-1480.)





**Fig. 4.** Reconstruction of neck contracture with a flap from the back. A female in her 30s underwent reconstruction of her anterior-neck contracture with a large 35 × 19-cm skin-pedicled flap from the back. The circumflex scapular vessels and the seventh dorsal intercostal perforators (D-ICAPs) were attached to the flap and then anastomosed to the facial vessels and transverse cervical vessels, respectively. The flap survived fully and the contracture was effectively released. (A) Preoperative view. (B) Flap design. (C) Immediately after surgery. (D) Three weeks after surgery. (With permission from the publisher; Ogawa R, Hyakusoku H, Murakami M. Color Doppler ultrasonography in the planning of microvascular augmented "super-thin" flaps. *Plast Reconstr Surg.* 2003 Sep;112(3):822-8.)

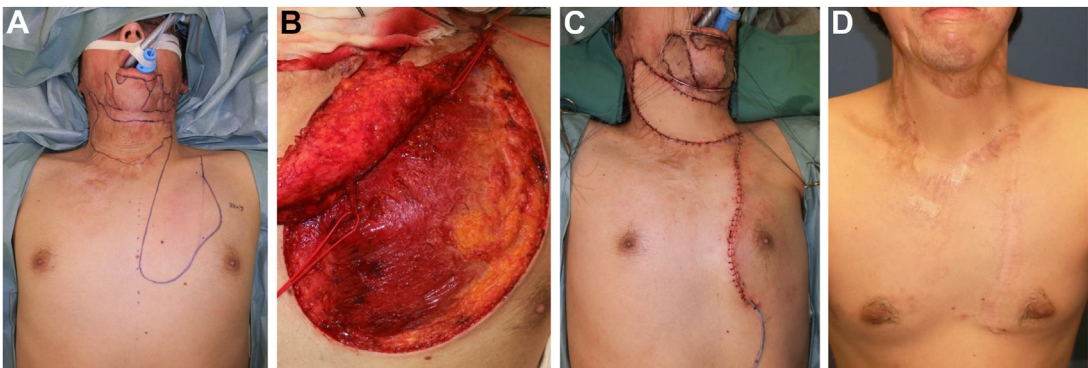
### Flap Thinness

The average skin thickness of the chin is 860  $\mu\text{m}$ , whereas that of the anterior neck is 1410  $\mu\text{m}$ .<sup>1</sup> In comparison, the supraclavicular area is very thin at 770  $\mu\text{m}$  (see **Table 1**). Thus, the supraclavicular artery flap is an excellent choice when prioritizing flap thinness. Since the average skin thickness of the anterior chest and back is 1440 and 1980  $\mu\text{m}$ , respectively, they can be used to reconstruct the 1410  $\mu\text{m}$ -thick anterior-neck skin with minimal discomfort. However, these flaps are not suitable for reconstructing the 860  $\mu\text{m}$ -thick chin skin because they can result in excessive thickness. Instead, very thin flaps such as super-thin flaps after primary fat-layer removal<sup>7</sup> or perforator flaps (discussed further in the following paragraphs)

should be used (see **Fig. 4**). Note also that after extensive burns, patients often lose weight. This can affect the thickness of the skin, meaning that thin flaps can often be harvested in burn patients without having to remove the fat. Conversely, as time progresses post-injury, the back and abdominal areas may accumulate fatty tissue, making the flaps thicker and necessitating fat removal. Patient weight loss and gain should be considered when selecting donor sites.

### FLAP SELECTION Pedicled Flaps

Flaps such as the pectoralis major, latissimus dorsi, and trapezius flaps can be pedicled and transplanted to the cervical region. However, due



**Fig. 5.** Reconstruction of neck contracture with a flap from the anterior chest. A male in his 20s underwent reconstruction of his anterior-neck contracture with a large 22 × 7-cm skin-pedicled flap from the anterior chest. The second internal mammary artery perforator was attached to the flap and anastomosed to the facial artery and veins. The flap survived fully and the contracture was effectively released. (A) Preoperative view. (B) Flap harvest. (C) Immediately after surgery. (D) One and a half years after the operation.

to the thickness of these flaps, they may not be the top choices for reconstruction solely for scar contracture. Pedicled perforator flaps around the neck include the facial artery perforator,<sup>12</sup> superior thyroid artery perforator,<sup>13</sup> and transverse cervical artery perforator flaps<sup>14</sup> while the perforator flap in the shoulder area is the supraclavicular flap. Those in the chest include the internal thoracic artery perforator flap or internal mammary artery perforator flap<sup>15</sup> and the pectoral intercostal artery perforator flap,<sup>16</sup> while the superficial cervical artery perforator flap<sup>17</sup> has been reported to be available in the back.

### **Free Flaps**

Essentially, all free flaps can be considered. However, the size, thickness, texture, color, and donor-site morbidity of the flap should be comprehensively assessed to determine suitability. Suitable free flaps for the neck include perforator flaps such as the thoracodorsal artery perforator flap<sup>18</sup> and the lateral thoracic artery perforator flap.<sup>19</sup>

### **Thinned Flaps**

Thinned flaps are those that are nourished by the SVN and have had as much of the fat layer removed as possible. They have been termed SVN flaps,<sup>20</sup> super-thin flaps,<sup>7</sup> and microdissected flaps<sup>21</sup> but the most common terms internationally are super-thin and ultra-thin flaps. These flaps are known to be useful options for cervical scar-contracture reconstruction. The flaps that have been developed with thinning in mind<sup>20</sup> include the cervico-pectoral (CP) (see **Fig. 5**), occipito-CP, occipito-cervico-dorsal (see **Fig. 4**), and occipito-cervico-shoulder flaps.

### **Expanded Flaps**

Expanders are especially suitable for children with limited donor skin or cases where cosmetic reconstruction is a priority.<sup>22</sup> Expanded flaps created around the clavicle or anterior chest are often used for neck reconstruction.<sup>23</sup> A disadvantage of the expander flap compared to regular flaps is that more surgeries are involved. However, a benefit is that the mechanical stimuli that are imposed on the endothelial cells by the expander promote angiogenesis within the flap. This results in a large thin flap that can be transplanted safely because it is less prone to postsurgical ischemia.

### **Prefabricated Flaps**

While it seems that fewer prefabricated flaps are currently being used for cervical scar-contracture reconstruction, they may still be useful for

simultaneous reconstruction of the beard with vascular bundle transplantation, or simultaneous reconstruction with deep tissues.<sup>4</sup> Prefabricated flaps may become useful again as tissue engineering technology progresses.

## **TIPS FOR HARVESTING THIN FLAPS SAFELY**

### ***Survival Area of Thin Skin Flaps***

Numerous anatomic studies have been conducted to determine the maximal area of thin skin flaps (including perforator flaps) that will survive.<sup>24</sup> However, the survival area of thin skin flaps can vary depending on physiologic conditions such as blood pressure fluctuations. Thus, it is essential to design thin flaps with some margin, retain the skin pedicle to promote venous perfusion, and employ techniques such as supercharging to ensure the safe and consistent adherence of thin flaps. For example, a supercharged flap with 2 or more pedicles can be generated from a large thin flap harvested from the chest or back by adding perforators to the periphery of the flap and anastomosing them to the recipient site. Currently, flap survival area is estimated by preoperatively evaluating the internal vessels of the flap by multidetector computed tomography (MDCT).<sup>25</sup> However, further research on the safe survival area of thin flaps is needed.

### ***Presence or Absence of Recipient Vessels***

Before surgery, the patency of recipient vessels should be confirmed by methods such as MDCT, color Doppler, or sound Doppler.<sup>7</sup> In cases where there is a risk of poor vascular anastomosis, single vascular pedicle flaps will not be options. Moreover, thin flaps may have weak venous return, so if it is possible to use 2 or more perforators, harvesting one as a skin pedicle can stabilize the blood flow of the flap. This often achieves sufficient venous perfusion, even if the skin pedicle is narrow.

### ***Defatting Procedure***

Since the skin of the chin and anterior neck is thin, a defatting procedure should be performed in a single stage before flap transplantation if possible. During this process, care should be taken to remove the fatty layer without damaging the SVN. Thus, the fat removal around the vascular stem should be minimal, and for other parts, the fat should be removed to the point where the SVN is visible, leaving the least amount of fatty layer.<sup>20</sup> If a skin pedicle can be retained in the flap, it is safe to aggressively remove its fat because not only does the removal of this excess

fat not affect the adherence of the flap, it can actually expand its adherence area.

## SUMMARY

Since the head and neck primarily extend and flex significantly in the anteroposterior direction, a key point is how to relieve tension in this direction. It is crucial to assess the extent and depth of reconstruction that is needed throughout the face-neck-anterior chest region, and to make the choice between techniques such as Z-plasty, skin grafting, super-thin flaps, and free flaps, including perforator flaps, on the basis of the principles outlined in this article.

## CLINICS CARE POINTS

- Tension sustains scar inflammation and increases the risk of hypertrophic scars and scar contracture.
- In head and neck reconstruction, the first priority is to release tension when selecting a flap.
- Skin pedicled flaps are more effective than island flaps in releasing tension, so they should be the first choice.
- For large flaps, supercharging the perforator branches can stabilize the blood flow.

## DISCLOSURE

There are no conflict of interests.

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