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Research Article

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Pre-expanded bipedicled visor flap: an ideal option for the reconstruction of upper and lower lip defects postburn in Asian males

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Abstract

Background: Reconstruction of upper and lower lip subunits is a complicated and elusive challenge. For patients affected by defects involving upper and lower lip subunits, a technique able to reconstruct both aesthetic units with matched colour, sufficient contours and similar texture would be ideal. In this study, we present our experience with upper and lower lip reconstruction using the pre-expanded bipedicled visor flap.

Methods: From January 2014 to January 2017, 12 male patients presenting with defects of the upper and lower lip subunits were treated using this surgical technique. After a period of expansion of the scalp flap of over 6 months, the bipedicled visor flap was raised from both the parietal regions and rotated to resurface the defect. Delay and section of the pedicle were then performed.

Results: Twelve male patients with postburn scars aged 22 to 48 years (mean: 34 years) were successfully treated with no major complications. The donor site was closed primarily in all cases. Subsequent flap debulking and minor revisions were performed under local anaesthesia between 6 and 12 months postoperatively.

Conclusions: The pre-expanded bipedicled visor flap provides an effective and reliable option for upper and lower lip reconstruction with excellent colour and texture. It is feasible to achieve these results simultaneously from a single donor site by using a pre-expanded bipedicled visor flap.

Key words: Postburn, Pre-expanded, Visor flap, Lip defect, Reconstruction

Background

Upper and lower lip defects caused by burn sequelae are extremely conspicuous and have a very high impact on patients' emotional status, resulting in their isolation from society. Achieving an ideal aesthetic appearance and relatively normal function always presents a challenge for plastic

surgeons. Skin grafting is widely used for the coverage of facial defects, especially in the early stage of burns management. This technique is simple and safe but tends to develop severe contraction and hyper/hypopigmentation in the long term. Moreover, the abnormal degradation in hair growth constantly harasses male patients [1]. The use of local flaps is limited by insufficient skin territory, tricky flap insetting and morbidity at the donor site [2–11]. Free flaps, such as chimeric anterolateral thigh (ALT) flaps [12,13] and free radial forearm (RFA) flaps [14–18] have been described as achieving immediate sufficient coverage but requiring high microsurgical skills from adequately trained surgeons. Notwithstanding that coverage can be achieved by the above approaches, unmatched colour, bulkiness due to a thick free flap and difference in texture often bring emotional discomfort to patients.

In male patients, burn sequelae and scar contraction result in facial disfigurement to the beard and moustache areas, thus constantly driving plastic surgeons to find an ideal reconstructive technique that is not only well vascularized but also hair-bearing. The visor flap was first introduced by Duformentel in 1919 [19]. Walton [20] then transplanted a free occipital hair-bearing flap for upper lip reconstruction. In 1989, Lyons et al. [21] described the superficial temporal artery hair-bearing free flap for upper lip reconstruction. In subsequent years, the expanded visor flap was used for postburn beard reconstruction [22]. Tissue expansion virtually eliminates donor site morbidity by providing additional skin tissue, allowing primary closure of the donor site, hence avoiding skin grafting.

Although the pre-expanded bipedicled visor flap seems to be an excellent solution for cervicofacial resurfacing, the multi-staged procedures and complicated technical requirements severely limit its applications, not only for plastic surgeons but also for patients. Moreover, although tissue expansion is considered an alternative delay procedure [23], both clinical and anecdotal experiences indicate that the blood supply of the expanded flap is sometimes unreliable. Partial necrosis and flap loss were occasionally observed in our early experiences. Besides, the conventional procedure requires skin grafting for the temporary treatment of pedicles, which leads to morbidity of a second donor site. As a result, few studies have been carried out on this issue recently. In this study, we present our experience in using a pre-expanded visor flap combined with additional delay for the management of extensive upper and lower lip defects. Postoperative revision and laser treatment can be performed to improve the beard in Asian males. This modified approach allows a simultaneous reconstruction of multiple facial subunits, with tissues of similar colour and texture, from a single donor site.

Methods

General information

From January 2014 to January 2017, our technique has been applied to 12 patients aged 22–48, with an average of 34 years. All patients suffered from severe postburn sequelae. Patients with injuries at the donor site, preexisting vascular or venous disease and neoplastic disease were excluded. Preoperative colour Doppler ultrasonography (CDU) was used to assess the presence and validity of superficial temporal vessels bilaterally. Patients with any absence or injury at either superficial temporal vessel were excluded. The present study is considered exempt from institutional review board approval since the data were collected retrospectively. Informed consent was obtained from all the patients. The surgical plan was discussed with patients and all the procedures were performed as described below.

Surgical anatomy

The visor flap vascular supply is guaranteed by the superficial temporal arteries (STA) and the superficial temporal veins (STV). The STA originates from the external carotid artery and then passes through the parotid gland under the facial nerve. At the upper preauricular level, it travels upward and lateral to the temporal mandibular joint. After crossing the zygomatic arch at about 1–1.5 cm anterior to the tragus, the STA enters the two layers of the temporoparietal fascia. Then it divides into the frontal and parietal branches in 90.9% of cases, as described by Beheiry et al. [24]. The frontal branch of the STA goes with the temporal branch of the facial nerve superiorly and finally nourishes the frontalis muscle, forehead skin and frontal scalp with the supratrochlear and supraorbital arteries by forming an anastomotic network [25–28]. The parietal branch, on the other hand, continues directly to the midline of the parietal scalp to the vertex. The STV usually runs adjacent to the STA at the proximal portion and then moves away from the artery. The STV usually travels posterior to the artery but in 9.1% of cases the vein was found anterior to the parietal branch of the STA [24].

Preoperative preparation

The shape and size of the expanders should always be estimated preoperatively. The largest commercially available expander that matches the patient's anatomy was chosen to achieve overestimated skin tissue after expansion. At this point, the surgeon's experiences came into play. According to our experience, the proper expander volume usually ranged from 500 ml to 800 ml. The patients were requested to shave their scalp completely and it was thoroughly cleaned 8 hours before the operation. Prophylactic antibiotic administration was applied. The location and course of the superficial temporal vessels were examined by CDU and marked to help identify the pedicle of the flap.

First stage: expander inset

The patient was placed in a supine position. All operations were performed under general anaesthesia. A horizontal incision on the midline, 1–2 cm within the hairline, was usually made for expander insertion. Generally, the longitudinal direction of the expander should be designed paralleled to the frontal axis. If the scar is narrow and involved both upper

and lower lips, the longitudinal direction of the expander could be designed vertical to the frontal axis instead. Care should be taken not to injure the temporal superficial fascia and expose bilaterally the pedicles or their branches during the dissection of the pocket. Before wound closure, the expander was checked carefully for any signs of obstruction or leak. After irrigating with antibiotic solution, the expander of the preoperative chosen size and shape was inserted into the subgaleal plane over the parietal region with the remote injection port embedded in the scalp. Saline at 15–20% of the indicated volume was inflated intraoperatively to spread the expander evenly and obliterate dead space. A suction drainage was placed and kept routinely for 2 days postoperatively.

Second stage: tissue expansion

The expansion process was initiated 2–3 weeks postoperatively. 0.9% NaCl was used for inflation with a 23-gauge needle at a frequency of 2–3 times per week. No more than 20% of total indicated volume was injected at any one time. The expander was filled to at least 2.5 times its indicated volume during a period ranging from 6 to 8 months.

The end point of expansion differed because of individual variations. However, according to our experience, expansion should not be terminated until the sagittal width of the expanded parietal scalp (Fig. 1curve a) surpassed the sum of the expander pocket width (Fig. 1curve b) and the maximum vertical width of the facial burn scar (Fig. 1curve c), if we took the instant intraoperative contraction of the pre-expanded flap into consideration. This can be expressed as

$$a > b + c$$

where a: skin tissue achieved by tissue expansion; b: width needed for donor site closure; and c: width needed for upper and lower facial resurfacing.

Once sufficient expansion was achieved, the third stage was performed.

Third stage: visor flap elevation and transfer

Patients were requested to shave and clean their scalp completely before the operation. Then, bilateral superficial temporal vessels were marked, with the aid of CDU, by an experienced physician.

The operation was performed in supine position under general anaesthesia. We first profiled the paper templates of normal subunits according to the contralateral side before scarectomy so that we could precisely perform the scarectomy following the 'subunit' principle (Figure 2). After scarectomy was performed and the peri-wound contractions were thoroughly released in the upper and lower lip regions, a detailed template of the surgical defect was then profiled and moved towards the expanded scalp for the landmark design of the visor flap. Both superficial temporal vessels should be included along the longitudinal axis of the newly designed flap. Furthermore, the actual flap size should be designed

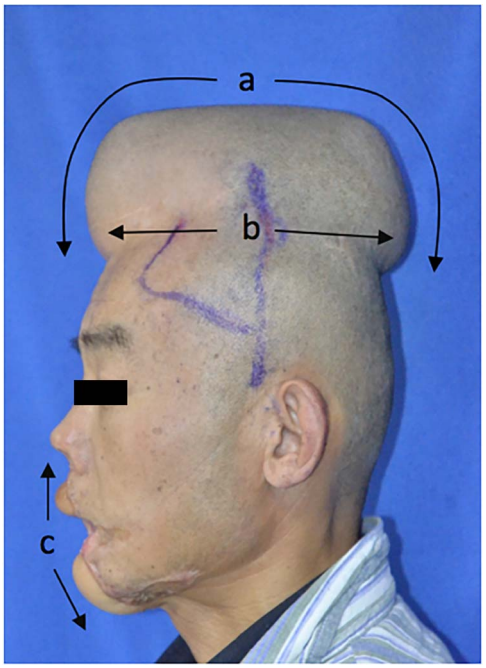

Figure 1. Preoperative estimate was performed. The sagittal width of the expanded parietal scalp (curve a), the width of pocket for expander (curve b) and the maximal vertical width of facial burn scar (curve c) were precisely measured

Figure 2. The resurfacing territory was marked by methylene blue according to upper and lower lip units

10% larger than the paper template because the expanded scalp will exhibit instant contraction as soon as the expander is removed. Direct closure of the donor site should be precisely ensured before the first incision.

Based on the landmark of superficial temporal vessels, a serrated incision was made on either side for pedicle exposure. Precise dissection was performed above the superficial temporal fascia layer until the pedicle could be achieved at a width of 2–3 cm. The pedicles were then elevated bilaterally within the superficial temporal fascia. Additional skeletonization and manipulation should be avoided to ensure a simple dissection and robust vascularization. (Figs 3 and 4).

Once the pedicles were properly dissected, the expander was removed and the visor flap was then elevated at the galea–periosteum space. Careful dissection was performed

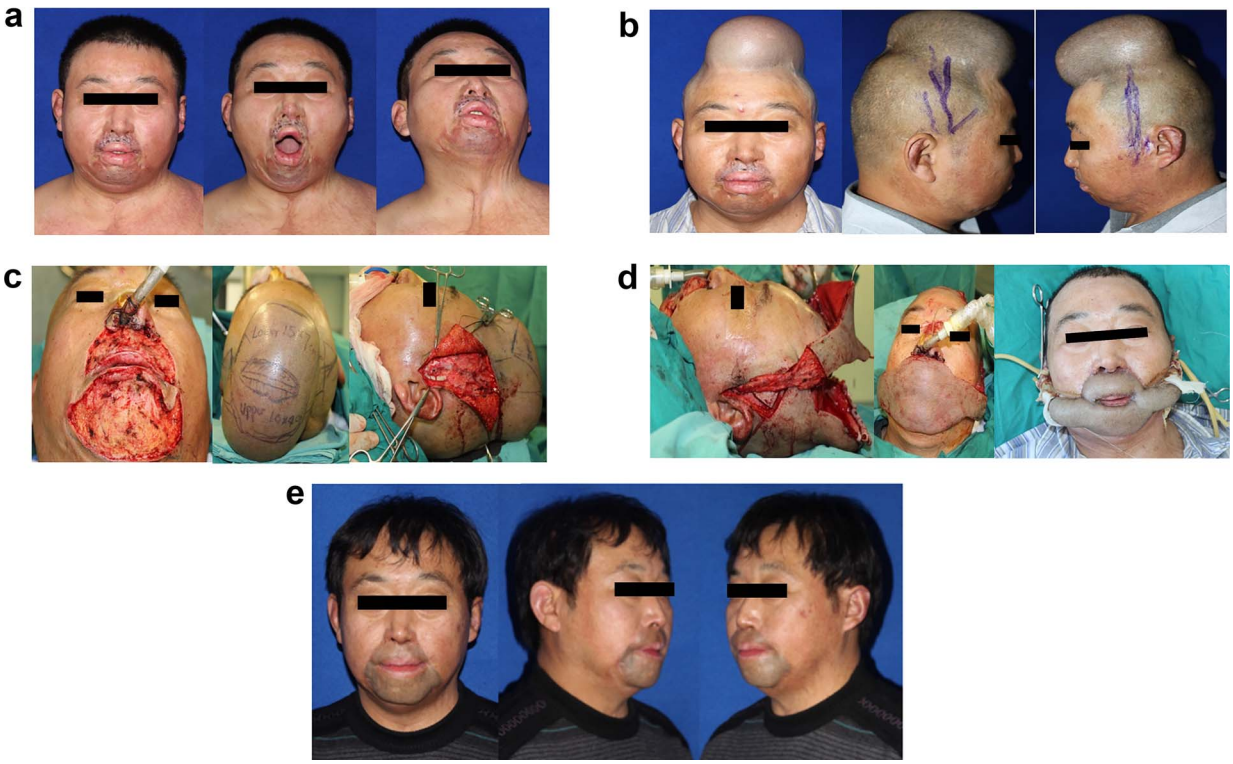

Figure 3. Case 1. A 47-year old man had severe burn scars in his upper and lower lips. (**a**) Preoperative view. (**b**) Patient underwent tissue expansion in scalp area. (**c**) scars were excised in upper and lower lip. Bipedicled visor flap was marked with facial landmarks according to the defect. Superficial temporary vessels were then exposed on either side. (**d**) Flap was harvested and sutured to recipient site and donor site was able to be closed primarily. Visor flap underwent delay and pedicle divisions. (**e**) The results at 12-month follow-up

maintaining the flap on one side connected to the contralateral side, resulting in a pre-expanded superficial temporal artery-based conjoined flap. The well-vascularized capsule formed around the expander was left intact and transposed as a part of the visor flap. Additional dissections of flap pedicles were performed only when insufficient mobility to the recipient site was found. Direct closure was performed at the donor site. After excising the scar tissue and releasing the fibrous synechiae at the recipient site, the flap was rotated and turned over to the exact contour of the defect. The anaesthetist was invited to disconnect the endotracheal tube temporarily to allow the flap to pass over the naso-oral region. This manoeuvre was carried out in a sterile fashion by the first surgeon assisted by the anaesthetist, who was asked to scrub in to complete this part of the procedure.

After haemostasis, the flap was double-checked for blood supply and then sutured into the lower facial defect. Six to eight self-made Vaseline gauzes were sutured at the mandibular region to maintain constant pressure, so as to reshape the flap contour and stimulate venous drainage. The donor site was closed by primary intention while suction drainages were left for 2 days postoperatively. A gastric tube can be placed intraoperatively in order to prevent infection for patients who underwent both upper and lower lip reconstruction. The pedicles were tubed and covered with Vaseline gauze. Dressings should be changed daily considering the exudation of the wound during the first week postoperatively. Starting from second postoperative week, as the granulation tissue covered the raw surface, the exudation usually ceased gradually. Patients followed a liquid diet through a gastric tube until the wound healed properly after surgery.

Fourth stage: delay and pedicle division

In order to ensure a reliable blood supply, the flap underwent delay for a period of 6 to 8 weeks. The two pedicles were clamped with a rubber band or silicone sheet for the training of vascularization. The frequency and duration of training increased gradually according to flap perfusion. Swelling, venous congestion or abnormal temperature of the flap should be tightly monitored. Although there are many techniques for flap monitoring such as indocyanine green (ICG), laser Doppler and transcutaneous oximetry, we believe that clinical observation stands as the mainstay in most cases. The flap increasingly achieved neovascularization, and thus could finally safely survive without bilateral superficial temporal vessels.

In order to ensure the survival of the visor flap, unilateral pedicle division and inset of the flap pedicle should be performed. The proximal side of the pedicle was thinned by trimming of the fat and subcutaneous tissue, then it was inserted back to the defect created during the harvesting procedure. Three weeks after the first pedicle division was performed, we performed division of the second pedicle using the same technique.

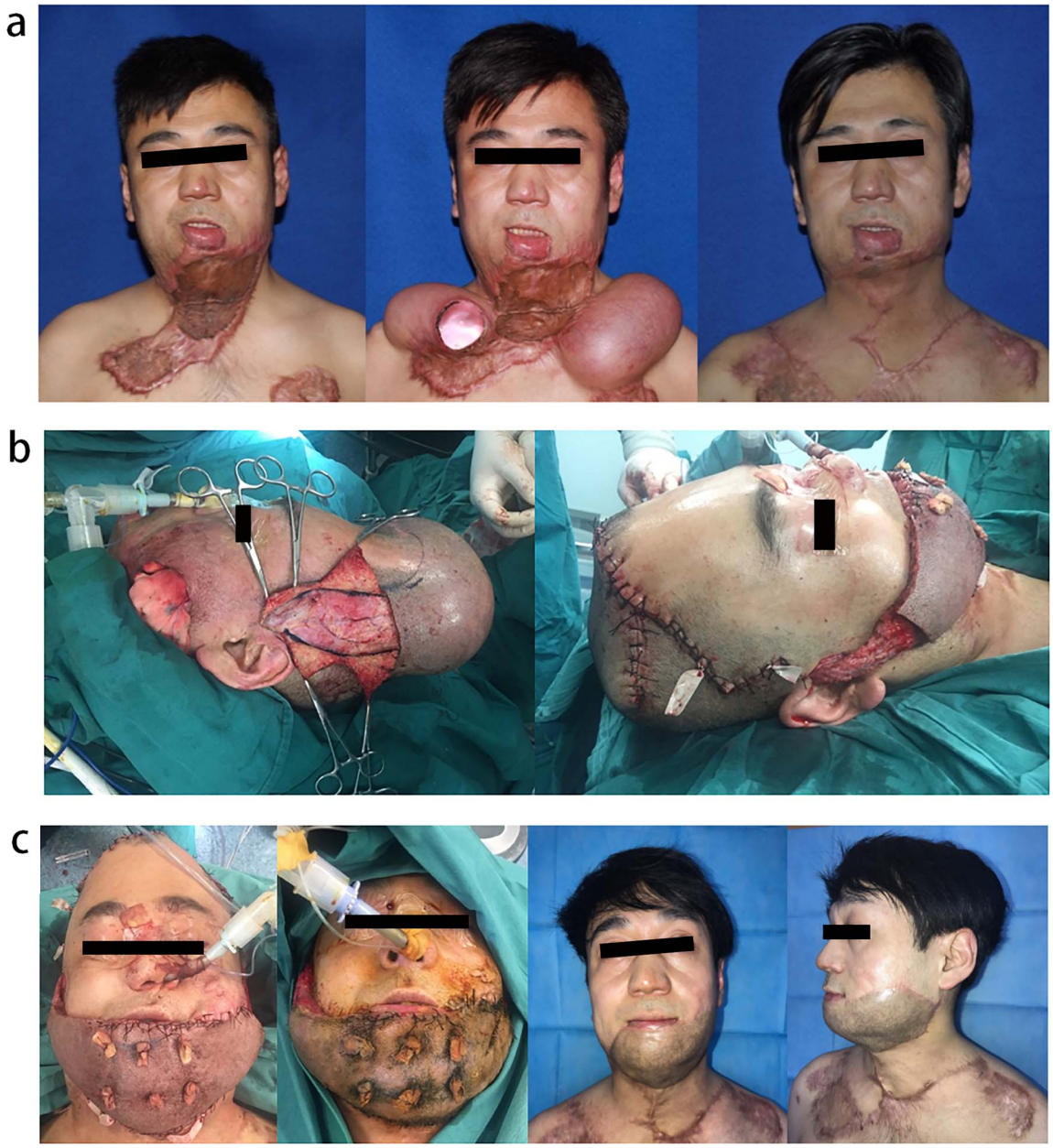

Figure 4. Case 2. A 32-year old man had severe burn scars involving his entire lower face and neck. (**a**) Preoperative view. The patient successfully underwent tissue expansion in cervical area. (**b**) Superficial temporary vessels were exposed on either side. Flap was harvested and sutured to recipient site. Donor site was closed primarily. (**c**) 6 Vaseline gauzes as compressive garment were used to enhance tissue adhesion. The visor flap was well vascularized with obvious hair growth after 6-weeks delay. The results at 6 and 24 months postsurgery were excellent

Some cases required further minor revisions that were performed 6–12 months postoperatively. Flap debulking and lipofilling significantly improved lower facial contour. Laser treatment was required for hair removal, particularly among Asian males.

Results

Excellent functional and cosmetic results were achieved in all our 12 subjects. Patients' age, features of the defect (aetiology, localization, size), donor site closure, complications and follow-up are detailed in Table 1. With our approach, the pre-expanded bipedicled visor flap was harvested for upper and lower lip reconstruction from one single donor site. Among all subjects, only one patient with a single pedicled flap had transitory venous insufficiency that resolved spontaneously. One patient had wound dehiscence due to local infection caused by pedicle exposure and only one partial necrosis at the middle portion of the bipedicled flap was observed. No other complications were observed and no microsurgical techniques were needed; all donor sites achieved primary closure with optimal aesthetic results. Some of the draw-

Table 1. Our series of 12 pre-expanded bipedicled visor flaps

Patient number	Pedicle style	Patient age (years)	Defect location (lips)	Cause	Defect size (cm)	Donor site closure	Complications and follow-up
1	Bipedicle	47	U&L	Burn	10×4; 15×7	Primary	None, 12 mo
2	Bipedicle	32	L	Burn	12×7	Primary	None, 24 mo
3	Bipedicle	35	U&L	Burn	9×5;12×6	Primary	None, 9 mo
4	Bipedicle	48	U&L	Burn	12×5; 14×6	Primary	None, 11 mo
5	Bipedicle	41	L	Burn	15×6	Primary	None, 12 mo
6	Bipedicle	37	L	Trauma	13×8	Primary	Wound dehiscence, 10 mo
7	Bipedicle	28	L	Burn	17×7	Primary	Partial necrosis at middle portion, 12 mo
8	Bipedicle	39	L	Burn	14×6	Primary	None, 9 mo
9	Bipedicle	22	U&L	Burn	14×5;14×7	Primary	None, 8 mo
10	Bipedicle	25	U&L	Burn	10×4; 17 × 6	Primary	None, 12 mo
11	Bipedicle	30	L	Burn	12×5	Primary	None, 8 mo
12	Single pedicle	24	U&L	Burn	11 × 5; 13 × 5	Primary	Transitory venous insufficiency, 24 mo

U&L upper and lower, *L* lower, *mo* months

backs of a such multi-staged technique include prolonged hospitalization, increased operative costs and reduced patient compliance. However, we believe it is still worthwhile for most patients considering the extraordinary outcomes of this approach.

Clinical case 1

A 47-year old man reported severe burn scars in his upper and lower lips and suffered from restriction in mouth opening (Fig. 3a). We placed a 500 ml expander under the scalp for the reconstruction of entire upper and lower lip units (Fig. 3b). The expander remained in place and was inflated until a volume of 1500 ml was reached (Fig. 3b). The patient then underwent the remaining stages of the reconstructive procedure as described above.

Scars at the upper and lower lip regions were first excised to allow a precise design of the visor flap on the expanded scalp. A serrated incision was then made on either side for exposure of the pedicle (Fig. 3c). The pedicles were carefully harvested at both sides and the flap was elevated at the galea–periosteum space. The flap was then sutured to the recipient site while the donor site was closed by primary intention. A horizontal incision was made to create the new oral fissure within the visor flap (Fig. 3d). The two pedicles remained as rare wound and dressings were changed daily for the first week during a delay period of 6 weeks in total. The visor flap was well vascularized with evident hair growth. After bilateral pedicle divisions were performed, excellent outcomes were observed at 12 months postoperatively (Fig. 3e).

Clinical case 2

A 32-year old man suffered from severe burn scars involving his entire lower face and neck. After substituting the scar with pre-expanded skin from the neck, mandibular scars were left for reconstruction (Fig. 4a). After being fully informed about the procedures and possible outcomes of the operations, the patient insisted on his healthy tissue on the right cheek being preserved, despite an asymmetric postoperative appearance. The patient then underwent the multi-staged procedures described above. A 500 ml expander was inserted during first stage of the operation. The expander was inflated with saline solution, reaching a volume of 2000 ml in 6 months. During the third stage, bilateral superficial temporal vessels were exposed carefully and a safe width for the pedicle was designed with ink for either side (Fig. 4b). The visor flap was then elevated and sutured to the recipient site. The donor site was directly closed intraoperatively while 6 self-made Vaseline gauzes were used to mimic the natural contour of the lower facial region (Fig. 4b, c). After a 6-week delay, the visor flap was well vascularized with obvious hair growth (Fig. 4c, left-middle). Pedicle divisions were then performed and excellent outcomes were observed at 6 months postoperatively (Fig. 4c, right-middle). After laser treatment, the patient showed an ideal appearance at 24 months postoperatively (Fig. 4c, right).

Discussion

Lower facial and cervical regions are often involved in severe postburn injuries because of their uncovered status in daily life. The grotesque appearance and constant functional loss caused by scars and contractions tortures the patients. Reconstruction of the cervical region with tissue expansion has already been widely reported [29,30, 31]. Concerning lower facial defects, the involvement of both upper and lower lip subunits drives plastic surgeons to seek a resurfacing technique able to offer matching colour and texture, pliability and minimal donor site morbidity. In the 1950s, Gonzalez [32] described the "regional aesthetic units" concept. According to his microscopic study, the thickness for upper and lower lip was measured as 2300 units and 1900 units, respectively (2000 units = 2.032 mm), indicating the feasibility of utilizing a single donor site for the reconstruction of both upper and lower lip regions. Using the tissue expansion technique,

sufficiently large scalp flaps can be harvested to achieve defect coverage and reconstruction. Moreover, a more detailed camouflage of beard and moustache can be achieved in male victims.

The visor flap has been a classic approach since it was first introduced by Duformentel [19]. The flap, based on bilateral superficial temporary vessels, allowed coverage of defects having a maximal width of 2–3 cm and resulted in severe donor site morbidity and alopecia at the very beginning of its application [33]. With the development and popularization of tissue expansion, the conventional visor flap was modified as a pre-expanded flap for both upper and lower lip resurfacing which allows primary closure of the donor site [22]. However, several drawbacks remained. (1) The inflation intervals and duration vary from patient to patient. An exact preoperative estimate and design is difficult to perform due to individual variations. (2) Skin grafting is used for the temporary coverage of bilateral pedicles during delay procedure, thus causing morbidity of a second donor site. (3) Partial necrosis and flap congestion happen occasionally but resulted in a total failure of the entire serial procedure. (4) Postoperative bushy hair on visor flap is not acceptable for some Asian males. (5) Multistaged procedures prolong hospitalization and cause patients psychological pressure.

Apart from a few relevant case reports, few studies in the literature explain a detailed procedure with a significant amount of cases. In this study, we presented our experience in solving these problems and offer a relatively reliable and straightforward procedure for the reconstruction of upper and lower lips.

When approaching reconstruction of facial units, precise dimensions and matching colour and texture all contribute to a vivid reconstruction outcome when compared to the original tissue. Tissue expansion is a common surgical procedure to grow extra skin for resurfacing defects. The pre-expanded visor flap offers relatively pliable expanded skin, but it also suffers from instant contraction [33]. Contraction of cells in normal skin tissue is caused by collagen fibres, elastic fibres and myofibroblasts. After expansion, these histologic components are significantly increased [34]. Normal fibroblasts gradually transform into myofibroblasts under constant stress during expansion and this phenomenon reverses 3 months after the mechanical stress is removed. As the expansion time is prolonged, the flap is considered to be in a status of static expansion, showing a relatively lower contraction rate [35]. Moreover, the pre-expansion stands as a delay procedure to enhance blood supply in the distal part of the flap [36]. Following the above theory, all patients in this study underwent a prolonged expansion period that lasted for more than 6 months. Among our patients, 500–800 ml expanders usually reached a terminal volume of 1500–2000 ml, depending on individual defect size. The endpoint of the expansion procedure has been described in the Methods section, above. Despite several mathematical methods that have been reported for the calculation of contraction rate [37], inflation of the maximum saline solution volume possible still stands as the best and most straightforward solution.

During our sequential procedures, an extremely meticulous and tedious dissection around the pedicles above and below superficial temporal fascia stands as the main component of the third stage. Unlike the studies cited above [20–22], we did not use split skin grafting as a temporary coverage of the pedicles before division, thus avoiding a second donor site morbidity. Instead, we maintained a 2–3 cm-wide fascial extension around the pedicles to provide the anatomical substrate for venous protection and drainage [38,39] and then covered this with Vaseline gauze for a delay treatment. Silver-containing dressings can be used to prevent infection if necessary. With careful daily dressing changing, no pedicle injury was observed in any of our patients. However, clinical manifestation of venous stasis was found in some of our early cases. Flap congestion and venous insufficiency were more likely to occur in the middle section of the visor flap. Tenna et al. [40] ascribed this self-limiting phenomenon to insufficient dissection of the venous branches in the pedicle. They performed a sub-follicular dissection to include more venous branches in the pedicle and improve flap vascularization. Additionally, the pedicle of the pre-expanded flap was located more peripherally when compared with a normal axial flap. As a result, the distance between the pedicle and the distal portion of the flap was longer [41]. As to the bipedicled visor flap, the middle portion stands as the distal part to either nutrient vessel. Consequently, we leveraged 6–8 tailored Vaseline gauzes as compressive garments to enhance tissue drainage using through-and-through mattress sutures in this area, thus both achieving a better balance in vascularization and reshaping the normal lower lip contour. Meanwhile, we selectively prolonged the delay duration to a period of over 6 weeks in certain patients according to evaluation during delay training. At this stage, some scientific monitoring methods such as laser Doppler, transcutaneous oximetry and indocyanine green provided us relative indications. Importantly, our method ensures a reliable blood supply for the flap while effectively avoiding skin grafting for the temporary coverage of pedicles.

We believe that the pre-expanded bipedicled visor flap is particularly suitable for the management of extensive post-burn scars in facial and cervical areas. With the help of tissue expansion in cervical and scalp areas, upper and lower lip resurfacing can be perfectly performed according to the 'subunit' principle. Even if there is insufficient healthy skin tissue available in the neck, the pre-expanded visor flap can flexibly provide a considerable amount of pliable tissue for partial cervical resurfacing. Second, the symmetrical cambered architecture of the visor flap constantly exerts a tension in its middle portion, thus preventing lower lip ectropion resulting from scar contractions. Although the flap may lose hair during the patient's middle age, the unwanted hair still remained an aesthetic concern among some of our Asian patients. Accordingly, the surgical design was then tailored to the patient's individual demand and an asymmetric flap was harvested for

the resurfacing of lower lip. Furthermore, long-pulse alexandrite (755 nm) and long-pulse diode (810 nm) laser treatment was applied to the flap for a long-lasting hair removal 2 months postoperatively. Although some hypertrophic scarring that remained after any minor revisions correlated with the extent of the initial burn, which is typically observed in Chinese patients, hyperpigmentation subsided gradually within months. The outcome proved to be promising at one-year follow-up and all the patients were extremely satisfied.

With our modified methods, we obtained a bipedicled pre-expanded island flap with sufficient dimension, reliable vascularity, optimal thickness and matching characteristics from a single donor site, allowing simultaneous and flexible coverage for upper and/or lower lip units. In some of our patients, partial cervical resurfacing was also achievable when a local pre-expanded flap was limited by lacking in healthy surrounding skin tissue. Microsurgical techniques or skin grafting were not necessary. All donor sites were closed by primary intention and could be easily camouflaged in mature hair. However, our method exhibits its own limitations as the multi-staged procedure stands as a long-running, sequential treatment that prolonged hospitalization time and increased expenses. Moreover, any failure or imprecision from each step would lead to a frustrating postoperative outcome. Therefore, highly specialized expertise is required from physicians for each step, such as tissue expansion, flap harvest and delay, lipofilling and laser treatment. Nevertheless, the extraordinary aesthetic and functional reconstruction outcomes achieved using this approach significantly improve patients' quality of life and salvages them from social isolation, making all the costs worthwhile and profound.

Conclusions

The present study shows that pre-expanded bipedicled visor flap provides us an effective and reliable option for upper and lower lip reconstruction with excellent aesthetic and functional outcome in Asian males. With our modified methods, the optimal postoperative results can be precisely achieved according to the subunit principle from one single donor site. Despite a multi-staged procedure being required, this approach significantly improves patients' quality of life and salvages them from social isolation. Therefore, the pre-expanded bipedicled visor flap has the potential to be popularized and further larger case series may still be essential to confirm the efficacy of our established techniques.

Abbreviations

ALT, anterolateral thigh; RFA, radial forearm; CDU, colour Doppler ultrasonography; STA, superficial temporal arteries; STV, superficial temporal veins; ICG, Indocyanine green

Supplementary material

Supplementary material is available at *Burns & Trauma Journal* online.

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Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

Yixin Zhang was the director of the technical refinements described and supervisor of this study; Peiru Min, Beniamino Brunetti and Rosa Salzillo wrote and revised this paper; Peiru Min, Zheming Pu, Weijie Su, Wenjing Xi, Zheng Zhang and Shaoqing Feng performed surgeries as leading surgeons and co-surgeons.
Peiru Min, Beniamino Brunetti and Jie Li contributed equally to this paper.

Ethics approval and consent to participate

The present study is considered exempt from institutional review board approval since the data was collected retrospectively. Informed consent was obtained from all the patients.

Consent for publication

All patients provided written informed consent for publication of pictures and personal data.

Conflicts of interest

The authors declare that they have no competing interests.

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