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Role of Free Flaps in Facial Burn Reconstructions

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Abstract

Traditionally, burn reconstructions have been performed by the use of skin grafting or local flaps. Recently free flaps are being used with increasing frequency. Although not very common in the head neck region, free flaps are mostly used for secondary reconstructions of cervicofacial contractures. We report the role of free flaps in postburn facial reconstructions, excluding neck and scalp burns.

Sixteen free flaps used for postburn facial reconstructions were reviewed retrospectively, during the period between 2003 and 2023. The etiology, indications, timing, location, choice of the flap, type of reconstruction, and outcomes were analyzed. Indications and type of reconstructions were categorized to correlate with flap choice. The age of the patients ranged between 8 and 40 years. The etiology included electrical burns in six cases, flame burns in eight cases, and acid burns in two cases. Nine defects were in the central part of the face including the nose and the chin. Two primary and 14 secondary reconstructions were performed using free flaps from lateral thigh in 11 cases, lateral arm in 2 free flaps cases, radial forearm in 2 free flaps cases, and the posterior auricular flap in 1 case. There were no total flap failures. Secondary procedures were needed in 10 of 13 evaluable patients.

Free flaps provide a good and safe option for selective postburn reconstructions in the face. The choice of flap mainly depends on the indication and type of reconstruction needed, apart from the availability of donor tissue and the surgeon's preference. Complex reconstructions may need larger and composite flaps to replace the components. Multiple secondary procedures are needed to achieve the objectives.

Keywords

- facial burn scars
- free flaps
- loss of lip
- scar nose
- functional reconstruction

Introduction

Postburn reconstruction in the head and neck has been a challenge, and usually involves multistaged procedures. The basic goal of the treatment is to improve the appearance while restoring the function. Historically, the mainstay of treatment for postburn scar contractures has been skin grafting or local flaps.[1]

With deeper facial burns (electrical, chemical, or fourth-degree burn in an epileptic), there may be a greater need to consider flap cover due to the defects that expose bone, or scars associated with loss of functional structures like the nose, ears, lips, etc.; the former raises the issue of coverage and the latter the issue of restoration of the critical structure and function. Local flaps, although preferred,[2] may not be available or inadequate for the reconstruction of extensive scar contractures, forcing to consider distant free flaps.

The early reports on use of free flaps for burn care by Harii et al[3] and Sharzer et al[4] were followed by few reports on the use of free flaps in the head and neck region, limited to

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extensive neck contracture, nose,[5] or scalp[6] reconstructions. In this study, we have analyzed the use of free flaps in postburn reconstructions of the face, excluding neck and scalp reconstructions. We tried to group the indications and type of reconstructions and correlated this with the selected flap choice.

Materials and Methods

All the patients who underwent postburn facial reconstructions using free flaps from 2003 to 2023 were included in this retrospective analysis. All the procedures were performed at a non–burn tertiary referral center. The collection of data included etiology of the burn, specific indication for flap cover, facial subregions with extensions into partial contiguous areas involved, choice of flap, choice of recipient vessels, flap outcome, and number of secondary procedures. Free flaps for postburn neck contractures or scalp wounds were excluded.

Indications for free flap were grouped as (1) defects needing a cover as to the exposed bone, (2) reconstruction of structures as in the nose, or (3) restoration of function such as the lip continence.

The types of reconstructions needed were grouped as either simple or complex for each category of indication:

- Simple (single unit; ►**Fig. 1**) or complex reconstructions (more than 2 units) for defect coverage (►**Fig. 2**).
- Simple (single-component) or complex reconstructions (multiple-component) (►**Figs. 3**–**5**) for structural reconstructions.
- Simple (single-component) or complex reconstructions (multiple-component) for functional restoration (►**Fig. 6**, ►**Video 1**).
- Aesthetic enhancement.

Video 1

Continent lip following complex functional reconstruction for the lower lip (►**Figs. 6**, **7**). Online content including video sequences viewable at: https://www.thieme-connect.com/products/ejournals/html/10.1055/s-0044-1790512.

The indication and type of reconstruction needed were correlated to the selection of flap choice.

All the surgical procedures began with dissection of the recipient vessels, followed by defect creation. The donor site flap elevation was started simultaneously along with recipient dissection.

Results

A total of 16 free flaps were used for postburn facial reconstruction. Age of the patients ranged from 8 to 40 years. There were 11 males and 5 females. The cause of burns included flame burns in 8 cases, electrical burns in 6 cases, and acid burns in 2 cases. Three of the eight flame burns were sustained during a seizure episode causing fourth-degree burns. In 10 of 16 cases, two or more facial units were affected. The timing of reconstruction varied between 9 days and 20 years. Two of these were operated within 6 weeks (primary reconstruction) and the rest were reconstructed between 2 months and 20 years (secondary reconstructions; ►**Table 1**).

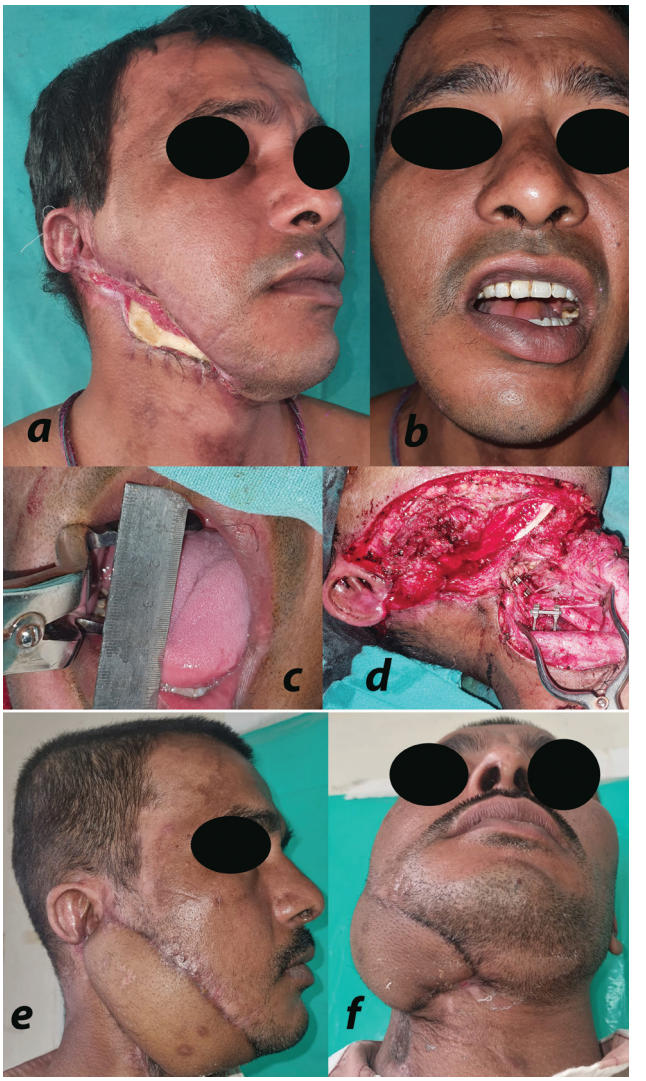

Fig. 1 Simple defect coverage. (**a**) Post electrical burn wound exposing the right lower jaw. (**b**) Restricted mouth opening due to scarring. (**c**) Intraoperative mouth opening. (**d**) exposed transverse cervical vessels, unsuitable for anastomosis; superior thyroid vessels were used. (**e, f**) Follow-up images after 6 months.

Correlation of the indications and type of reconstruction with the choice of free flap is described in ►**Table 2**.

Overall, 8 anterolateral thigh (ALT) flaps, 1 ALT vastus lateralis (VL) muscle flap for free functioning muscle transfer (FFMT), 1 ALT VL composite flap, 1 tensor fascia lata (TFL) flap, 2 lateral arm, 1 postauricular flap, and 2 radial artery forearm flaps (RAFFs) were used.

Facial vessels were the most commonly used recipient vessels (in 10 cases). Superficial temporal vessels were used

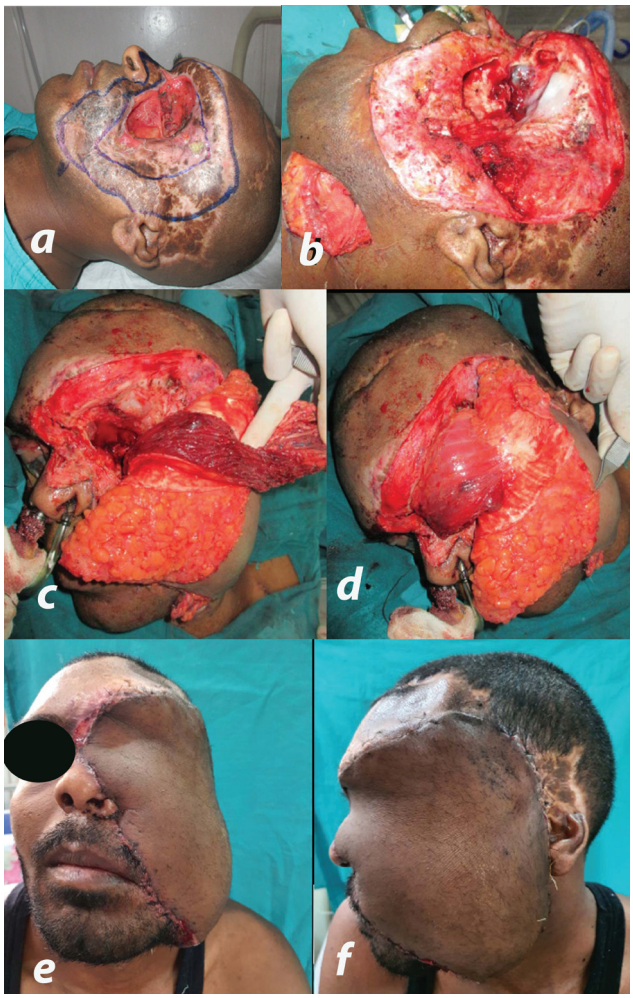

Fig. 2 Complex defect coverage. (**a**) Post electric burn sequelae involving orbit with loss of eye, granulating wounds over the sinuses and trismus. (**b**) Excision defect exposing the dura with leak, repaired with DuraGen. (**c, d**) Vastus lateralis anterolateral thigh (ALT) composite flap used for skin coverage and cavity filling. (**e, f**) Uneventful healing at follow-up of 3 months prior to lower flap thinning.

in two cases, and transverse cervical vessels, superior thyroid artery, lingual artery, and angular vessels were used in one case each, when facial vessels were not the choice or not available.

There were three re-explorations; two patients needed re-anastomosis of an artery and vein and the other needed hematoma drainage at the site of the pedicle. There was no flap loss.

Partial flap necrosis at the noncritical part of the flap occurred in four flaps. Two of these needed excision and split skin grafting, and another two improved with releasing skin sutures. Only two of all donor sites could be closed primarily.

Secondary Procedures

Flap thinning, flap readjustment, and scar revisions were the most common secondary procedures, performed in 11 cases. Although indicated, in view of associated co morbidity, secondary procedure was deferred in one patient; four patients were lost to follow-up and one has been planned for secondary procedures. The follow-up period ranged from 3 months to 10 years.

Discussion

Postburn facial reconstruction is challenging considering the complex structural and functional anatomy, mainly in the central face.

Recent developments in burn care and reconstructive techniques have improved the treatment outcomes following burn injuries. As rightly mentioned by Sabapathy et al,[7] the burn surgeon must be adept in all reconstructive techniques from skin grafting to tissue expanders and microsurgery to obtain the best outcomes.

Gókalan et al[8] exclusively analyzed 123 postburn reconstructions of facial deformities and categorized various reconstructive techniques into essential procedures affecting the functional goals and elective late procedures for aesthetic restorations. Free skin flaps were recommended for larger areas, even though they are bulky in appearance.

Zan et al[9] classified the postburn facial deformities into partial unit (type I), total unit (type II), multiple units (type III), and total/subtotal face (type IV) based on involvement and correlated with their reconstructive techniques. Most of the defects were covered using pedicled pre-expanded, prefabricated flaps. Seven defects of multiple units or total/subtotal facial deformities (types III and IV) needed free internal mammary artery perforator flaps, for a better aesthetic outcome.

In this series, we considered all the procedures as essential reconstructions irrespective of timing and tried to group the indications and type of reconstruction needed into three categories and then correlated with the selection of flap choice.

All the flaps chosen were skin flaps; the ALT was the preferred donor on account of availability, possibility of variable size, thickness, and various components of the flap for versatile reconstructions and two-team approach. The lateral arm donor site was preferred over the radial forearm flap either because of nonavailability or because of a relatively poorer donor outcome expected following radial forearm flap harvest. The only posterior auricular free flap (►**Figs. 3**–**45**) was done due to non availability of the forehead donor site for replacement of scarred nasal skin. Skin flaps with muscle and tendon as components were used for complex functional restorations.

De Lorenzi et al[10] reported a series of 53 secondary burn free flap reconstructions of 39 patients. Only 4 of 15 head and neck free flaps were used for non-neck burn contractures using the scapular flap with or without pre-expansion; no details of the facial defects were available in study. Of the only three flaps that failed, two were in the head and neck region; one radial forearm and one lateral arm needing a second free flap.

Baumeister et al[11] reported a series of 75 burn-related free flap transfers, for a cohort of mainly high-voltage electrical limb injuries. Twenty different donor sites were used; only four of these were facial reconstructions primarily

Fig. 3 Complex structural reconstruction. Postburn scarring of the entire nose with loss of projection and alar cartilages; forehead scarred precluding forehead flap usage.

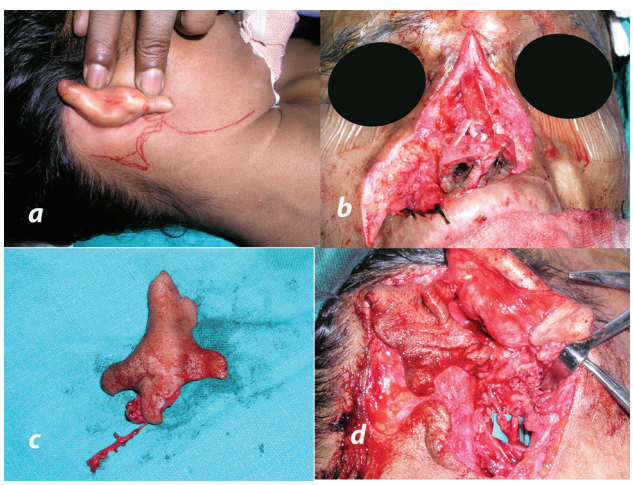

Fig. 4 (**a**) Image showing marking of postauricular free flap. (**b**) Reconstruction of nasal cartilaginous framework with costal cartilage grafts. (**c**) Harvested postauricular free flap. (**d**) At completion of anastomosis to angular vessels and prior to nasal skin inset.

Fig. 5 Follow-up images with good nasal skin and acceptable nasal projection after 18 months before scar revisions.

using the parascapular flap or large musculocutaneous flaps; they reported a 10% failure rate.

The limitations of donor site closure for the scapular flap and the possible need for pre-expansion can be avoided by using the ALT flap even at the cost of using split skin graft if the donor site cannot be closed primarily. In the event of limitation of donor site, a thought can be given to pre-expand the ALT donor site to permit primary closure after flap harvest. We did not use any pre-expanded flaps.

Parrett et al[12] reported 36 free flaps for the head and neck region over 17 years, of which 20 were for hypertrophic scars (appearance) and 16 were for exposed bone or cartilage; 23 flaps were used for the face, mostly (60%) using the prefabricated or prelaminated flaps from the scapular or ALT donor site. Two flaps failed and six flaps had partial necrosis needing secondary skin grafting. The authors observed that the use of prefabrication reduced the incidence of secondary procedures like flap thinning and adjustment from 64 to 36% in view of thinner and patterned flaps.

Fig. 6 Complex functional reconstruction. (**a**) Complex defect after electric burn with loss of lower lip subunit beyond the modiolus and exposed mandible and alveolus. (**b**) Following recreation of defect. (**c**) Harvested vastus lateralis anterolateral thigh (ALT) composite flap with nerve to the vastus lateralis. (**d**) Nerve coaptation done between the nerve to the vastus lateralis and the marginal mandibular nerve. (**e**) Inset given to the modiolus on one side and the orbicularis oris on the other side.

Fig. 7 Follow-up image after flap thinning and adjustment with a functional lower lip and acceptable oral competence.

Lee et al[13] preferred the radial forearm donor site for scar replacement of the chin and submental area of defect size between 90 and 100 cm^2. The authors did not mention what was done at the donor site, but it is reasonable to assume split thickness skin grafting was done.

We avoid the radial forearm donor site and prefer the lateral arm flap for smaller defects and ALT for larger defects. The advantage of either flap over the scapular flap is the ability to avoid a position change during surgery.

Although the radial forearm flap affords the possibility of transfer of functional elements like the palmaris longus, this can be justified in smaller defects with a lesser concern for donor morbidity. When the defects are large or the need for functional units is more, the thigh donor site using the ALT and the VL (►**Figs. 6**, **7**) may be more reliable (►**Video 1**) with a lesser impact at the donor site.

Yen et al[14] reported six cases of postburn resurfacing of the nose using a variety of flaps—the ulnar forearm, the ALT, and the medial sural artery perforator flap with simultaneous cartilage grafts with good aesthetic results, emphasizing the point that the choice of flap can be subject to the familiarity of the surgeons and individual availability in a particular patient. In spite of the tailored choice of flap, each case needed an average of 4.5 revision surgeries for optimal result.

Where there is a need for thin flap, primarily thinned supra-facial ALT flap can be used to provide a proper contour; such a flap is needed in the central part of the face extending from the forehead to the chin (►**Figs. 8**–**10**).

The alternatives for thin flaps are the use of tissue expansion, where adequate neck or cheek skin is available, or the use of flap prefabrication, which permits the use of limited distant donor site.

Yao ST[15] first described prefabrication, implanting the vascular pedicle to a distant donor site and transferring the flap. Pribaz et al[16] reported at least 7 of 15 prefabricated free flaps from distant sites specifically for burn defects of the lip, nose, ear, and cheek, stating the advantages of optimal use of available donor sites in burn patients.

Tissue expansion has an established role in the management of postburn deformities, depending on the availability of local tissues. Kalra et al[17] compared the use of tissue expander and free parascapular flap in extensive facial burn scar reconstructions and stated that free parascapular flaps may provide a superior alternative to tissue expansion because of its own set of limitations and complications.

A major concern about large free flaps in the face has been the thickness of the flap, masking the facial expressions, and the color match. Secondary surgical procedures like defatting and liposuction can be performed if the flap is bulky. Recent techniques of flap prefabrication, prelamination,[18] pre-expansion,[19] and "super-thin" flaps[20] have improved the quality of free flaps, allowing thinner, customized flaps with a better color match.

De Lorenzi et al[10] argue that similar to skin grafts, perfect color match is not achievable with distant donor flaps, and in a burn patient with extensive scarring, it may not be relevant because of a mix of variable color and texture already present.

Table 1 Details of postburn facial reconstructions using free flaps

Sl. no.	Time gap	Etiology	Facial subunit	Reconstruction	Choice of flap	Recipient vessels	Complications	Secondary procedure
1	9 d	EB	LF: Rt lower face, 1 U	SDC	ALT	FA, CFV		Thinning 1
2	2 mo	EB	LF: Rt lower face, 1 U	SDC	ALT	STh A, EJV	Venous thrombosis	Awaiting thinning
3	20 y	AB	CF forehead and eyelids, 1 U	SDC	LAF	SteV	Partial tip necrosis, SSG	None
4	2.4 y	FB	LF, 3 U	CDC	TFL	FA, CFV		Thinning 1
5	14 y	FB	CF: 3 U	CDC	ALT	FA, CFV		No FU
6	1.5 y	EB	LF: orbital, midface, 2 U	CDC	ALT + VL	FA, CFV		Thinning, adjustment 2
7	2 y	FB	CF: lower face, 2 U	CDC	ALT	FA, CFV		Thinning
8	3 y	FB	LF: Rt half, 2 U	CDC	RAFF	FA, EJV, and AJV		No FU
9	1 mo	EB	CF: forehead, both eyes up to root of the nose, 3 U	CDC	ALT	STV, EJV		Thinning and adjustment 3
10	4.5 y	FB	LF: Rt side face, 3 U	CDC	ALT	LA, EJV		No FU
11	2.5 y	AB	CF: loss of alae, 3 U	CSR	PAF	Angular vessels		Adjustment 1
12	13 y	EB	CF: nose, 1 U	CSR	RAFF	FA, CFV		Thinning 2
13	2 y	AB	CF: nose, 1 U	CSR	Prelaminated LAF	FA, CFV		Adjustment, lost to FU
14	4 mo	EB	CF: lower lip, 1 U	CFR	ALT VL FFMT	FA, CFV		Contouring 2
15	1.5 y	EB	Composite lower lateral face, 2 U	CFR	ALT	TCA, EJV	Re-exploration, hematoma evacuation, partial necrosis	No FU
16	4 y	FB	CF: perioral, >3 U	SFR	ALT	FA, CFV		Procedures deferred due to comorbidities

Abbreviations: AJV, anterior jugular vein; ALT, anterolateral thigh flap; CDC, complex defect coverage; CF, central face; CFR, complex functional reconstruction; CFV, common facial vein; CSR, complex structural reconstruction; EJV, external jugular vein; FA, facial artery; FA, flap adjustment; FB, EB, AB, flame, electrical, acid Burn; FFMT, free functioning muscle flap; FT, flap thinning; FU, follow-up; LAF, lateral arm flap; LF, lateral face; PAF, posterior auricular flap; RAFF, radial artery forearm flap; SDC, simple defect coverage; SFR, simple functional reconstruction; SSG, split skin grafting; STeV, superficial temporal vessels; STh, superior thyroid artery; TCA, transverse cervical artery; TFL, tensor fascia lata; U, units; VL, vastus lateralis muscle.

Table 2 Details of indication and type of reconstruction in relation to the flap choice

Reconstruction	Indication	No. of cases	Choice of flap
Simple defect coverage	Exposed bone; mandible: 2; frontal bone: 1	3	2 ALT, 1 lateral arm flap
Complex defect coverage	Complex multiple unit involvement (6), with exposed frontal bone	7	4 ALT, 1 ALT VL, 1 TFL, 1 RAFF
Simple structural reconstruction		0	
Complex structural reconstruction	Ala; dorsum with coverage: 1 lining; prelamination: 1	3	1 postauricular flap, 1 radial forearm flap, 1 prelaminated lateral arm flap
Simple functional reconstruction	Microstomia release with coverage of multiple units	1	ALT
Complex functional reconstruction	Total lower lip reconstruction with VL FFMT: 1, PO complex lower midface defect with necrosed alveoli of mandible and maxilla severe trismus	2	ALT VL FFMT, ALT

Abbreviations: ALT, anterolateral thigh flap; FFMT, free functioning muscle transfer; PO, postoperative; RAFA, radial artery forearm flap; TFL, tensor fascia lata flap; VL, vastus lateralis muscle.

Fig. 8 An 8-year-old child with postburn scarring over the perioral region with trismus and scarred nasal skin.

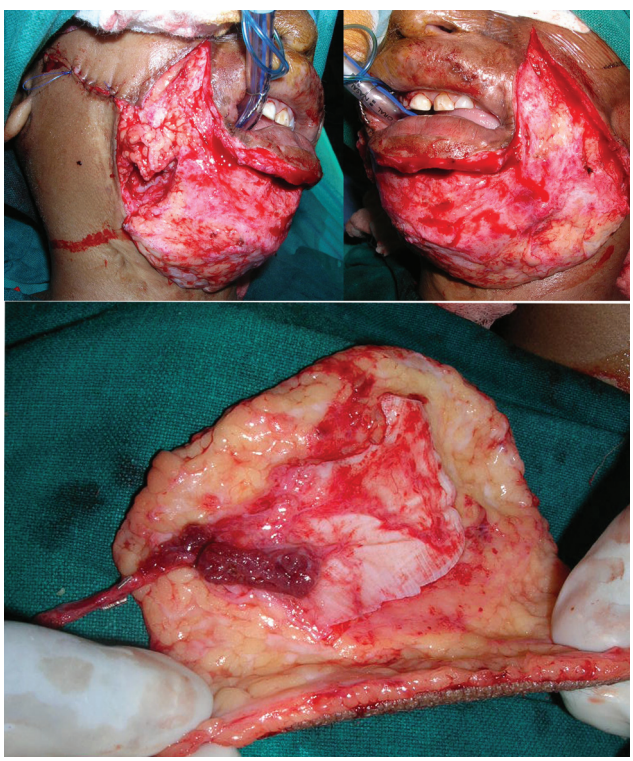

Fig. 9 Above: two views of excision skin defect of scar over the chin, submental region, and bilateral nasolabial region. Below: primarily thinned anterolateral thigh.

Use of free flaps for postburn reconstruction is not common in the literature. Platt et al[21] reported only 9 of 604 (1.5%) burns were reconstructed using free flaps, while De Lorenzi et al[10] reported the use of free flaps in 1.8% of cases.

De Lorenzi et al[10] reported on 39 free flaps with a failure rate of 8%. Abramson et al[22] reported on 47 flaps for secondary reconstruction, with 8 flaps for the face and a failure rate of 4%. Baumeister et al[11] reported 10% failure in burn injuries and 19% failure in electrical burn injuries with an overall failure rate of 23% in primary reconstructions (<6 weeks) and no failures in secondary reconstructions. Timing is an important consideration, especially in primary reconstructions where the physiological status is altered. We had no failures either in primary or secondary reconstructions.

In a systematic review, Jabir et al[23] concluded that free flaps are the preferred option to provide cover in both primary and secondary reconstructive surgeries in deeper burns while cautioning that free flaps have a higher failure rate in primary reconstruction (11.46%) than in secondary reconstruction (1.38%).

The face has 14 facial subunits.[24] Each unit may have different reconstructive requirements and the same unit may be reconstructed using different options including free flaps depending on the extent of involvement, specific indication for reconstruction and availability of donor tissues. In the situation where no local options are available, free flaps can provide large amounts of vascularized tissue

Fig. 10 Last follow-up images after 8 years with thin, pliable tissue over the previously scarred area of the lip and chin; an additional forehead flap had been done interim to replace the scarred nasal skin also.

with various components for various reconstructive requirements. The type of reconstruction required for a specific indication may guide the choice of flap.

Conclusion

There is a definite need to consider free flaps for postburn reconstruction of the face either for structural or for functional replacement. The choice of flap depends on the indication and type of reconstruction apart from the availability of donor tissue and the surgeon's preference. Multiple secondary procedures may be needed to achieve the objective. Free flaps provide a good and safe option for selective posturn reconstruction of the face.

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Conflict of Interest
None declared.

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