Postburn Head and Neck Reconstruction: An Algorithmic Approach

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Background: Optimizing functional and aesthetic outcomes in postburn head and neck reconstruction remains a surgical challenge. Recurrent contractures, impaired range of motion, and disfigurement because of disruption of the aesthetic subunits of the face, can result in poor patient satisfaction and ultimately, contribute to social isolation of the patient. In an effort to improve the quality of life of these patients, this study evaluates different surgical approaches with an emphasis on tissue expansion of free and regional flaps.

Methods: Regional and free-flap reconstruction was performed in 20 patients (26 flaps) with severe postburn head and neck contractures. To minimize donor site morbidity and obtain large amounts of thin and pliable tissue, pre-expansion was performed in all patients treated with locoregional flap reconstructions (12/12), and 62% (8/14) of patients with free-flap reconstructions. Algorithms regarding pre- and intraoperative decision-making are discussed, and complications between the techniques as well as long-term (mean follow-up 3 years) results are analyzed.

Results: Complications, including tissue expander infection with need for removal or exchange, partial or full flap loss, were evaluated and occurred in 25% (3/12) of patients with locoregional and 36% (5/14) of patients receiving free-flap reconstructions. Secondary revision surgery was performed in 33% (4/12) of locoregional flaps and 93% (13/14) of free flaps.

Conclusions: Both locoregional as well as distant tissue transfers have their role in postburn head and neck reconstruction, whereas pre-expansion remains an invaluable tool. Paying attention to the presented principles and keeping the importance of aesthetic facial subunits in mind, range of motion, aesthetics, and patient satisfaction were improved long term in all our patients, while minimizing donor site morbidity.

Key Words: Burn, contracture, head and neck flap reconstruction, pre-expansion, aesthetics

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Unfortunately, the head and neck area remains the most frequently affected anatomic area involved in burn injuries.[1] The resulting disfigurement because of scarring, and especially the often-developing contractures, may severely limit the patients functional and social rehabilitation.[2] As such, the ultimate goals of postburn reconstruction have virtually remained unchanged in that the ideal reconstruction, includes aggressive and complete release of all contractures and replacement with tissue of matching quality compared with the remaining face and surrounding areas. Although doing so, adhering to the principles of reconstructing the facial subunits should always be considered.[3] Especially, the neck with its propensity to develop severe contractures and its aesthetic importance, deserves utmost attention.[4]

Despite advancements in postburn head and neck reconstruction, such as the advent of free-tissue transfer, achieving optimal long-term results with high patient satisfaction remains a surgical challenge.[5] Without doubt, more recent descriptions of techniques such as pre-expansion of free- and regional axial island flaps, have all contributed in achieving this goal.[6,7] Pre-expansion of flaps can provide large surface and thin, pliable tissues. These features may be helpful when trying to reconstruct contour in the head and neck area. The groin and scapular flaps are especially suited given their tissue quality and donor site characteristics.[8,9]

Although sometimes argued to be time consuming, costly, and of poor tissue matching quality,[7] we find that pre-expanded free-tissue transfer still plays its role in postburn head and neck reconstruction. Similarly, given the ease of harvest and transfer as well as optimal color and texture match, pre-expanded axial (ie, supra- and infraclavicular island) flaps remain an important tool in the plastic surgeons' armamentarium.

Appropriate patient selection will ultimately remain the most critical factor. In an effort to further improve outcomes and keeping all recent surgical evolution in mind, we have analyzed our surgical decision-making and results in reconstructing severe postburn contractures during a 10-year period.

PATIENTS AND METHODS

A retrospective chart review was performed of all patients suffering from severe head and neck burn contractures between 2004 and 2014 treated at a major European Burn Center (Table 1). During this time, 20 patients (13 women and 7 men) underwent head or neck reconstruction with a total of 26 flaps, either pre-expanded or regular free flaps (9 groin-, 2 parascapular-, 1 anterolateral thigh (ALT)-, 1 extended lateral arm-, 1 temporal flap) or pre-expanded locoregional flaps (6 supraclavicular-, 2 infraclavicular-, 1 temporal-, and 3 local flaps; Table 2). Median age of all patients was 27 years (8–43 years), and mean follow-up was 3 years (3 months–7 years).

Expansions were performed with tissue expanders (Mentor Corporation, Irving, TX) for free flaps ranging from 50–750 cc, and for locoregional flaps ranging from 250–700 cc.

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TABLE 1. Patient Demographics

No	Age (year)	Sex	Comorbidities	Smoking Status	BMI
1	32	F	s/p myocarditis	N	39.1
2	31	F	hypotonia, GERD	N	15.8
3	18	F	–	N	17.9
4	8	M	–	N	21.2
5	26	F	–	N	20.4
6	21	M	–	N	23.5
7	23	M	–	Y	20.1
8	34	M	–	N	20.2
9	43	F	GERD, depression	n	29,3
10	23	F	–	Y	23.2
11	31	F	–	N	35.4
12	28	F	–	Y	222
13	12	M	–	N	24.6
14	20	M	GERD	Y	23.1
15	41	F	s/p DVT, inhalation trauma	N	28.3
16	13	F	–	N	17.3
17	28	F	depression	Y	16.4
18	33	F	–	N	19.8
19	19	F	–	N	20.3
20	43	M	–	N	23.5

BMI, body mass index; GERD, gastroesophageal reflux disease.

Defect and corresponding free-flap size ranged from 10×4 cm to 35×18 cm in patients where free flaps were used. For locoregional flaps, defect and flap sizes measured 18×7 cm to 20×16 cm. Extensive physical therapy according to a strict in-house protocol was part of the postoperative regimen in all patients.

CLINICAL EXAMPLES

Patient 1: Locoregional Flap Based Reconstruction

Patient No. 5: A 26-year-old woman sustained a burn injury (superficial and deep dermal) at the age of 6 months involving her head, neck, and right upper extremity [approximately 15% total body surface area (TBSA)]. During the acute phase of the burn injury, the patient was initially treated in different hospitals in her home country by early tangential debridement, hand amputation, and placement of several meshed split thickness skin grafts. After multiple surgeries, the patient was presented at our department with diverse hypertrophic, contracted scars in the area of the right arm and right face with lagophthalmus and alopecia (35×20 cm in size) of approximately 70% of her head (Fig. 1A-B). After an initial evaluation, given that only the face, but not the shoulders were burned, facial reconstruction with locoregional flaps in several stages was planned. In the first stage, an elliptical 500 cc expander (Mentor®) was implanted in the left occipital region, and another elliptical 700 cc expander (Mentor®) in the right supraclavicular region. After 12 weeks of weakly expansion, contracture release and scar correction were performed by scar excision. Occipitally, the scar was partially excised and reconstructed by a local advancement flap of the pre-expanded, unaffected scalp skin. Scars in the right hemiface were excised taking aesthetic subunits into consideration, resulting in a final defect of 20×16 cm in size. This defect was reconstructed by the regional pre-expanded supraclavicular flap. Primary closure of the donor wounds was achieved without tension. After 9 days of hospital stay, the patient was discharged without any complications. At three weeks postoperatively, the first debulking was performed. Nine weeks later, the patient showed signs of an ectropium formation of the right eye, and a lateral canthopexy was performed accordingly. After an additional 2 months, another 700 cc (Mentor®) expander was implanted in the parieto-occipital region for further scalp expansion and reconstruction of the allopecia. After 5 weeks of expansion the patient showed a small area of beginning dehiscence in the anterior portion of the wound, and a revision was performed promptly to avoid further complications. After 5 days of hospital stay the patient was discharged. At 9 months follow-up, the patient showed no functional restrictions and was very satisfied with the aesthetic result (Fig. 2A-B). Minor revisionsurgeries and scar corrections are planned in the future to further optimize the results.

Patient 2: Free-Flap-Based Reconstruction

Patient No. 10: A 23-year-old woman sustained burn injuries (superficial/deep dermal) at the age of 4 years involving her neck and upper chest (approximately 6% TBSA). Initially, the patient was treated in a different hospital during the acute phase of the burn injury, including debridement and skin grafting of the anterior neck. She consequently developed significant burn contractures in her neck resulting in functional restrictions. The patient was referred to our department and presented with a mentosternal burn contracture and deficiency of neck reclination and rotation (Fig. 3A-B). After an initial evaluation, anterior neck reconstruction using a pre-expanded free groin flap in 2 stages was planned. Local flaps were no option in this patient, because she refused to have any more scars in her upper torso/shoulder area. In the first stage of the reconstruction, a 750 cc tissue elliptical expander (Mentor®) was inserted through an 8 cm incision, corresponding to the lower border of the groin flap on the left side. Serial expansion was started 3 weeks postop and performed on a weekly basis. After 6 weeks of expansion, the expander had to be exchanged because of skin perforation. Expansion was then continued 12 weeks to a flap size sufficient to resurface the whole aesthetic unit of the neck was obtained.

In the second stage of the reconstruction, contracture release was performed by full thickness scar excision up to the limits of the aesthetic units of the neck. In complete reclination, the defect size measured 22×11 cm. The free pre-expanded groin flap (22×12 cm in size) was used to reconstruct the defect. Primary closure of the donor wound was achieved without tension. After 9 days of hospital stay, the patient was discharged without any complications. At 10 weeks postop, the first debulking was performed. During that time the patient also showed signs of seroma formation at the donor site, which was revised accordingly. After 12 weeks, a second debulking session and scar revision were performed. Postoperatively, the tip of the flap showed signs of malperfusion, which fully recovered under conservative therapy. The patient regained complete range and was very satisfied with the final surgical result.

At a 5-year follow-up, she presented without functional restrictions (Fig. 4A-B).

RESULTS

Complications, including the donor site and the expander related complications, were divided into major and minor complications. Total flap loss and any complications related to the expander or donor site were declared as major complications, and occurred in 31 % (8/26) of all patients (Table 2). Flap malperfusion with loss of less than 10 % of tissue (tip necrosis), were declared minor complications and occurred in 15 % (4/26) of all patients (Table 2).

Secondary revision surgery, including Z-plasties, readvancement or thinning of flaps were performed in 89% (8/9) of free groin flaps, 100% (2/2) of free regular parascapular flaps,100%

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TABLE 2. Complications in Postburn Head and Neck Reconstruction

No	Flap Type/Size (cm)	Pre-expanded/ Expander size (cc)	Reconstructed area	Expander-Related Complication	Donor Site Complication	Recipient Site Complication	Revision surgery
Locoregional Flaps							
1	Supraclavicular flap/22 × 13	Y/700	Left face	Port luxation → expander exchanged	n	Distal flap malperfusion* → secondary closure	1×debulking, lateral canthopexy
	Supraclavicular flap/22 × 13	Y/700	Right face	N	N	N	3× scar revision, lateral canthopexy
2	Infraclavicular flap/22 × 14	Y/550	Neck	N	N	Distal flap malperfusion* → secondary closure	N
3	Supraclavicular flap right/20 × 10	Y/250	Neck	N	N	Distal flap malperfusion* → secondary closure	N
	Supraclavicular flap left/20 × 12	Y/400	Neck	Perforation → expander exchanged	N	N	N
4	Supraclavicular flap/20 × 12	Y/300	Left cheek	N	N	N	1× debulking
5	Supraclavicular flap/20 × 16	Y/700	Right face	N	Hypertrophic scar → triamcinolon injection	N	2× lateral canthopexy, debulking, scar revision
	Local flap parieto-occipital	Y/500	Head	N	N	N	N
	Local flap parieto-occipital	Y/700	Head	Small pressure sore†	N	N	N
6	Infraclavicular flap/20 × 12	Y/700	Neck	N	N	N	N
7	Local flap neck	Y/400	Right face	N	N	N	N
8	Temporal flap/18 × 7	Y/400	Right cheek	N	N	Total temporal flap loss → free ALT	N
Free Flaps							
8	Free ALT/20 × 7	N	Right cheek	–	N	N	1× debulking, scar revision
9	Free groin flap/35 × 18	Y/700	neck	N	N	N	1× debulking, scar revision
10	Free groin flap/25 × 9	Y/750	Neck	Perforation → expander exchanged	Seroma	Distal flap malperfusion* after debulking → conservative therapy	2× debulking
11	Free groin flap/22 × 12	Y/700	Neck	N	N	Distal flap malperfusion* → secondary closure	1× debulking
12	Free groin flap/22 × 12	Y/700	Neck	N	N	Total free groin flap loss → STSG → free parascapular flap	N
	Free parascapular flap/26 × 11	N	Neck	–	N	N	2× debulking, scar revision
13	Free groin flap/24 × 16	Y/600		N	N	Distal flap malperfusion* after debulking → FTSG	3× debulking, scar revision
14	Free groin flap/22 × 12	N	Left neck	–	Hematoma	N	2× debulking, scar revision
15	Free groin flap/29 × 12	Y/600	Neck	Perforation → expander exchanged	N	N	3× debulking, scar revision
16	Free parascapular flap/20 × 7	N	Neck	–	N	N	3× scar revision
17	Free groin flap/21 × 9	N	Neck	–	N	N	1× debulking, 2× scar revision, STSG
18	Free groin flap/26 × 12	Y/550	Neck	N	Hematoma	N	4× debulking, scar revision
19	Free ELAF/10 × 4	N	Upper lip	–	N	N	1× debulking, scar revision
20	Free temporal flap/10 × 5	Y/50	Upper lip	N	N	N	2× debulking, scar revision

ALT, anterolateral thighplit-thickness skin grafts; ELAF, extended lateral arm ap; FTSG, full-thickness skin grafts; STSG, split-thickness skin grafts.

*Flap malperfusion with loss of <10% of tissue.

†Immediate reconstruction was performed to avoid further complication.

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FIGURE 1. Patient 1 preoperatively. Preoperative lateral oblique view at the age of 4 years (A) and frontal view at 26 years (B) demonstrating the affected areas with hypo- and hyperpigmentation, severe scarring, and alopecia.

(1/1) of ALT flaps,100 % (1/1) of free temporal flaps, 100 % (1/1) free extended lateral arm flaps, 67% (4/6) of regional supraclavicular flaps, 0% (0/1) of infraclavicular flaps, 0% (0/3) of local flaps, and 0% (0/1) of regional temporal flaps.

FIGURE 2. Patient 1postoperatively. Postoperative frontal (A) and lateral oblique (B) views at 9 months after reconstruction with a pre-expanded supraclavicular flap.

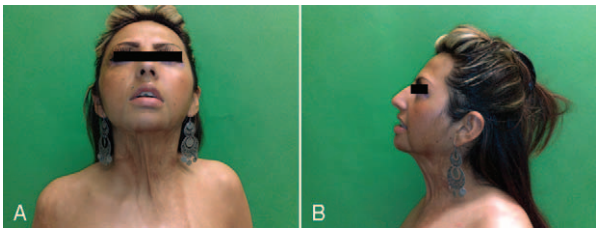

FIGURE 3. Patient 2 preoperatively. Preoperative frontal (A) and left lateral (B) views demonstrating the severe neck contracture and decreased range of motion in a 23-year-old woman.

DISCUSSION

Achieving good functional and aesthetic outcomes when treating severe postburn head and neck contractures remains a challenging task. Simple release of contractures followed by large area skin-grafting can be considered, but will unlikely achieve satisfactory outcomes given the high rate of contracture recurrence, especially when using split-thickness grafts. Furthermore, skin grafts may be of poor color match and are also not as pliable as natural face- and neck skin, which can impair range of motion.[10,11] As such, several studies have reported on the advantages of attempting to replace like with like as much as possible. Following the obligatory complete scar release, this may include using locoregional or free flaps.[12–14]

Especially, when large areas need to be resurfaced, pre-expansion of tissue has proven to be a valuable tool for several reasons. It allows to cover more surface while enabling to close the donor site primarily in most patients. Furthermore, studies have shown that pre-expansion increases vascularization and hence reliability and possible amount of tissue to be transferred.[15–17] It also causes atrophy of all expanded tissue layers except the epidermis, which makes the flaps thinner, an important fact when trying to improve delicate face and neck contour.[18]

Similar to others, in our study, we found that pre-expanded flaps from the head, neck, and shoulder may be advantageous when compared with free-tissue transfer. For one, this tissue is usually of ideal tissue characteristics, including color and texture.[19] Furthermore, it may, in comparison, also be easier and faster to perform, while obviating the risks and cost associated with free-tissue transfer.[20,21]

In many severely burned patients, the shoulder and torso area, however, may be affected as well, making free-tissue transfer

FIGURE 4. Patient 2 postoperatively. Postoperative frontal (A) and left lateral (B) views at five years after reconstruction with a free pre-expanded groin flap. Range of motion and appearance are significantly improved.

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necessary. Reflecting our preferred donor sites for reconstruction of the head and neck area and to aid with the operative decision making, we implemented the following decision tree:

The algorithm (Fig. 5) is based on the observations and experiences gained from this series and follow several principles: when not affected by the scarring, local options should be preferred as long as the donor site can be closed primarily. Considering the local options, supraclavicular flaps are preferred over infraclavicular flaps, given their greater proximity to the affected areas as well as better skin and tissue match compared with infraclavicular flaps.

In patients when locoregional options are not available, we prefer pre-expanded groin flaps as the next choice as, in comparison to scapular- and para-scapular flaps, these generally show thinner dermis, are easier to expand, and can be harvested without patient repositioning in a simultaneous fashion to the scar excision and vessel exposure in the neck.

Overall, we found that complication rates in the presented select group of patients remains exceedingly high. This may in part be because of the fact that reporting of complications in surgery is not yet standardized enough in our opinion. Especially, the distinction between minor and major complications appears to be quite vague in the literature. We therefore opted to include all notes of complications, even small wound dehiscences, etc., which did not impair the final outcome, in our series. Furthermore, the patient collective reported upon with deep-dermal and subdermal burn injuries and subsequent severe scarring with impaired tissue qualities makes this specific group prone to complications when rearranging tissues. Although ultimate results may be very satisfactory, the high complication rates encountered also underline that achieving good outcomes are usually the result of a long journey for both surgeons and patients, a situation both of which need to be aware of.

In respect to microsurgical tissue transfer, while technically challenging, we found that overall complication rates of free-flap reconstructions were similar to locoregional options. It must be noted that such operative strategy requires an experienced team to assure good outcomes. Especially, in poor or underdeveloped countries, where a majority of burns occur, free-flap surgery may thus not be a viable option.

Regarding the pre-expansion of tissue, it appears that this approach comes at the cost of multiple surgeries, risk of expander infection and extrusion, which occurred in 20% (4/20) of our patients, as well as at the cost of multiple office visits and a somewhat disfigured appearance during the expansion phase. Evaluating our long-term results, we, however, found that the benefits of expansion far outweigh its disadvantages. Even a partial flap loss, for instance in the distal portions of a locoregional flap, still justifies the procedure as ultimately both function and aesthetic appearance are significantly improved by virtue of the underlying scar release and by replacing 80% to 90% of the burned tissues with healthy, pliable skin.

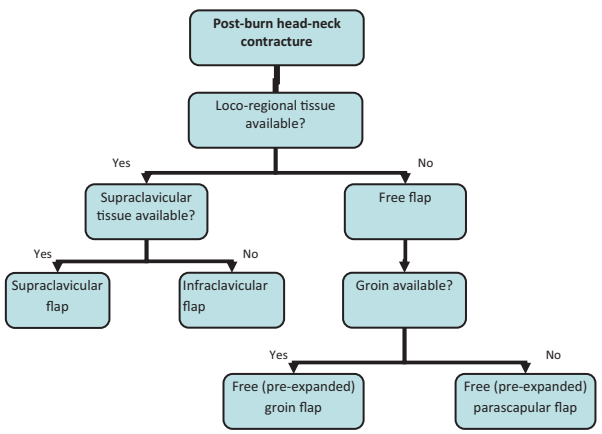

FIGURE 5. Treatment algorithm for surgical correction of postburn head and neck contractures.

As noted by Rose et al,[22] paying attention to reconstructing entire subunits of the face is advocated and was always ultimate goal in our reconstructions. Especially, recreating a sharp and precisely defined submental angle appears important. As both local and free flaps have a tendency to tent over the submental area upon inset, we found that securing the flap to the mandible and hyoid bone by means of several pexy sutures is essential. Furthermore, all patients should wear a neck lift compression garnement for 2 months postoperatively.

In one of the largest series published to date, Zan et al[23] regarded the pedicled infraclavicular flap as the workhorse flap in the reconstruction of head and neck defects after burn injury, because the pivot point of the supplying vessels is located approximately 2 cm above the middle point of the clavicula,[24] which is closer to the defects than the pivot point of other anterior chest flaps. If the supplying vessels are not sufficient, his group suggests the IMAP flap or in case of extensive defects of the face the prefabricated anterior chest for flap for reconstruction.[23] Because of obvious linear scarring, which causes deformations of the chest and asymmetry in the position of the nipples, we prefer the use of a free groin or parascapular flap in these cases.

In summary, our experience and evolution of techniques in treating severe postburn head and neck reconstruction has shown us that paying attention to certain pearls and principles may aid in optimizing outcomes for these patients.

These include

- Complete and aggressive release of all scars and contractures, including the underlying platysma[25]
- Using, given better tissue match, locoregional options unless the donor site tissue is burned
- Using pre-expansion to improve vascularity and pliability of the tissue, while minimizing donor site morbidity
- Paying attention to reconstructing entire subunits of the face and recreating a distinct submental angle to optimize aesthetics
- Early and aggressive physical therapy to prevent fibrosis in the interface between the flap and the underlying wound bed to maintain full range of motion and prevent recurrence of scar contractures.[26]

In respect to expander implantation the following principles should be adhered to:

- Expander size should be chosen with maximum size to allow most efficient expansion of skin; however, the expander base needs to have flush contact to the underlying tissues. Furthermore, expansion needs to be feasible without creating folds in the expander as these will result in focal points of high pressure because of the sharp edges, and thus increase the risk of skin penetration
- Before expander insertion, the skin should be prepped again and gloves changed (one touch technique)
- Expansion should be commenced 14 to 21 days postoperatively and excessive tension because of overfilling should be avoided.
- Adhering to these principles and the presented decision tree, good long-term functional and aesthetic results may be achieved while minimizing number of surgeries, associated costs, and morbidity of the patients.

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CONCLUSIONS

We present a long-term follow-up series of severe head and neck burn patients, treated by transfer of local and distant tissue with a focus on pre-expansion. Overall, complications rates remain high in this challenging patient population; however, we found that adhering to the presented principles, while keeping recent surgical advances in mind, can aid to minimize such complications and optimize functional and aesthetic outcomes of severely burned patients.

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