CME

Postburn Reconstruction of the Face and Neck

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Learning Objectives: After studying this article, the participant should be able to: 1. Understand the cardinal principles in the management of postburn deformities in the face and neck. 2. Understand reconstruction of specific subsites in the face and neck affected by burn contracture. 3. Acquire knowledge about the various techniques of burn reconstruction of the face and neck. 4. Grasp technical nuances and select appropriate surgical options for individual cases.

Summary: Postburn contractures in the face and neck region are multifactorial in origin and difficult to prevent in extensive burns. Facial burns lead to distortion of anatomical landmarks, causing aesthetic, functional, and psychological problems. Each subunit of the face is unique in structure; thus, the surgeon needs to adjust the timing of surgery and the technique according to region and the severity of contracture. Contracture of one unit, especially that of the neck and forehead, can exaggerate the contracture in neighboring subunits. The role of these extrinsic influences must be considered while sequencing surgical procedures. The burn surgeon must be adept in all reconstructive surgery techniques from skin grafting to tissue expanders to microsurgery to obtain the best outcomes. Surgery must be followed up with long-term physical therapy and psychological rehabilitation to help burn survivors with head and neck contractures to integrate back into society. (*Plast. Reconstr. Surg.* 150: 1326e, 2022.)

The face, to an individual, is one of the richest and most powerful tools to express emotion, to serve as a mode of communication, and to provide unique identity in social interactions.[1] However, when it is disfigured, patients experience loss of self-worth. Fortunately, the available reconstructive techniques allow us to provide most of them with a face with which to face the world.

Involvement of the head and neck in burns occurs in approximately 60 percent of patients who have more than 50 percent of total body surface area burns.[2,3] The skin of the face is thick in most places except over the eyelids and the neck.[4] It also has an excellent blood supply and healing potential, so most head and neck burns are treated conservatively.[5] If the wounds over the face and neck do not heal within 3 weeks, probably because of deep burns and infection, the burns might need excision and grafting.[4,6] When the wounds are left unhealed, there is a concentric reduction in the size of the wound.[7–9] Except for the scalp and the forehead, the skin over the head and neck is mobile. Therefore, it offers significantly less resistance for scar contraction, leading to ectropion of the eyelids, eversion of the lips, neck contractures, shrinkage of the oral commissures, and ear and nasal deformities (Fig. 1). Cardinal principles in managing postburn deformities in the head and neck are summarized in Table 1.[10–18]

TIMING AND SEQUENCE OF SURGERY

Surgical intervention for postburn contractures should be avoided during the active phase of healing and scarring (i.e., while the scar is still immature and highly vascular). This normally takes approximately 1 year. Before undertaking contracture surgery, the scar must be mature and become soft, supple, and less vascular. A highly vascular scar bleeds more during surgery and causes difficulty in obtaining perfect hemostasis, resulting in poor graft take, leading to recurrence

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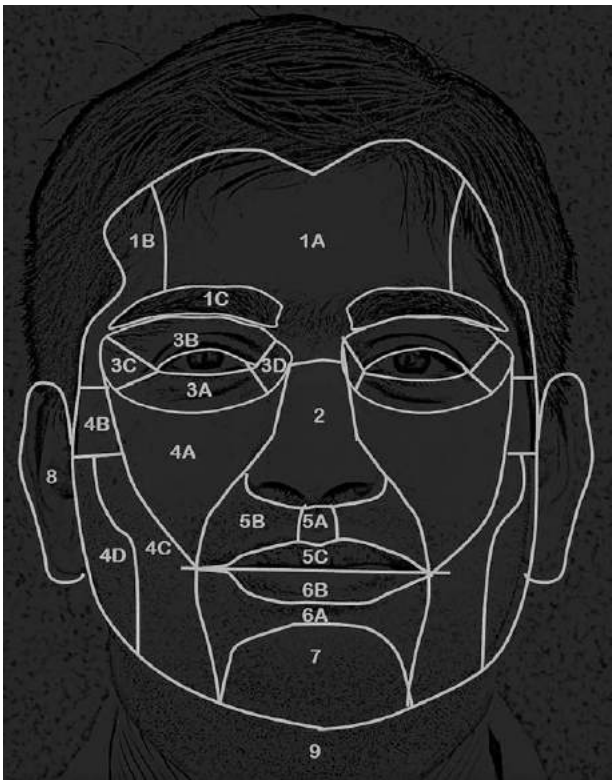

Fig. 1. Aesthetic units and subunits of the face. *1*, forehead unit (*1A*, central subunit; *1B*, lateral subunit; *1C*, eyebrow subunit); *2*, nasal unit; *3*, eyelid units (*3A*, lower lid unit; *3B*, upper lid unit; *3C*, lateral canthal subunit; *3D*, medical canthal subunit); *4*, cheek unit (*4A*, medial subunit; *4B*, zygomatic subunit; *4C*, buccal subunit; *4D*, lateral subunit); *5*, upper lip unit (*5A*, philtrum subunit; *5B*, lateral subunit; *5C*, mucosal subunit); *6*, lower lip unit (*6A*, central subunit; *6B*, mucosal subunit); *7*, mental unit; *8*, auricular unit; *9*, neck unit.

of contracture. Second, operating on an active, highly vascular scar while the wound bed is still contracting elicits a strong local response, resulting in further contraction and a less-than-ideal outcome. Furthermore, an immature scar is responsive to physical therapy treatments, resulting in significant recovery. Some mild contractures may improve over time, with a better final result than if they were surgically controlled. Surgery is advised when improvement has plateaued during physical therapy. However, there are exceptions to the norm of waiting until the scar matures when they pose danger to critical functions (Table 2).

RECONSTRUCTION OF SPECIFIC AREAS

Neck

Neck contractures are disabling to the patient, as they limit extension and lateral rotation of the neck. The severely scarred neck pulls the soft tissue above and below, producing extrinsic contractures, resulting in ectropion of the eyes, oral incompetence, drooling of saliva, and distortion of the breast and axilla. Thus, before correcting the everted lips or the ectropion of the eyelids, neck contracture has to be addressed first.[3,12] Often, the extent of correction required in facial contractures will be reduced once the extrinsic component is removed (Fig. 2).

The restriction in neck extension could create difficulties in endotracheal intubation for general

Table 1. Cardinal Principles in the Management of Postburn Facial Contractures

- The scars should be allowed to become mature, soft, and supple before undertaking surgery for contractures.[10,11] Releasing an immature scar can result in excess bleeding and further inflammation and contraction.[12,13]
- Contractures around the eyes and the oral cavity should be released early, even with immature scars, to prevent exposure keratitis, blindness, and difficulty in eating and anesthesia.[12,14]
- The neck should be released first, reducing the extrinsic pull and tension on the other facial structures. With the extrinsic pull reduced, a lesser release in the facial scars would suffice. Besides, initial neck release helps in the administration of anesthesia for subsequent procedures.[15] The neck release can also be combined with the release of the other facial structures such as the eyelids and the lower lip.
- Two methods can accomplish contracture release. One, by incisional release in which we cut across the contracture; and the other, in which we excise all the contracted scar tissue.[14] However, the amount of skin replacement is higher in the excisional release. Therefore, scar contracture release should be performed primarily by an incisional release, as it decreases the area of skin resurfacing needed.
- At the end of the incisional release, fishtailing of the corners should be performed to prevent linear contractures at the sides.[13]
- If areas of hypopigmentation, hypertrophic scars, unstable scars, discharging sinuses are present, these areas should also be excised. Excision of these areas may require more soft-tissue cover compared to incisional release.
- The release of the scar obtained on the table is the maximum release that one can obtain; thus, the maximum release of the contracture should be obtained during surgery.
- One can easily underestimate the amount of skin graft needed after the release of the contracture; planning the extent of soft tissue needed to resurface the defect should be done only after the release of the contracture. If >50% of the facial subunit is involved, the whole subunit must be resurfaced[4,16] (Fig 1). If the defect involves more than one subunit, each subunit can be resurfaced by different methods.[17]
- After contracture release, the defects should be resurfaced by thin tissues such as skin graft or a thin flap to avoid contour deformities. Thick flaps on the face cause the loss of facial expression.[17,18] People "smile under the flap."
- Aftercare of the graft sites with massage, compression garment, and splint must be continued for at least 6 mo to 1 yr.

anesthesia.[20] Associated contractures of the oral cavity such as microstomia could add to the difficulty.[15] Fiberoptic intubation has surmounted the problem to a large extent.[20,21] When that facility is unavailable or blind nasal intubation is not successful, an incisional release of the neck contracture is performed under local anesthesia using the tumescent technique.[20,22,23] Once sufficient extension is gained, endotracheal intubation is performed, and surgery is continued. Tracheostomy is usually avoided.

Surgery is performed with full neck extension, with soft rolls under the shoulder and multiple head rings to support the neck. As the contracture is released, the head rings are sequentially removed to let the head drop down to obtain full release. Band-like contractures and less severe contractures can be released with Z-plasty and local flaps (Fig. 3). The tip of the Z-plasty flap can be raised at a 90-degree angle for a few millimeters and immediately changed to the marked orientation. This prevents tip necrosis, especially when performed in burn patients, and also makes suturing easier. Although local flaps are good to perform, they are helpful only after release of mild contractures.[24] Contractures occur because of loss of skin, and losses need to be compensated.

A critical outcome determinant of neck contracture release is the full release of the contracture. A transverse incision is made across the neck contracture from one midlateral line to the other midlateral line. An incision above the level of the

Table 2. Situations Needing Early Contracture Release

Ectropion of the eyelids, particularly the upper eyelid, posing a risk of keratoconjunctivitis, corneal ulceration, scarring, or perforation, with possible vision loss
Severe neck contracture, with inability to see forward
Microstomia, causing difficulty in eating and maintaining oral hygiene
Burn contractures, with adjacent raw areas that require skin cover
Contractures, with infected hypertrophic scars and abscesses that require excision and drainage to heal

Fig. 2. (*Above*, *left*) Severe mentosternal contracture. In addition to neck contracture, there is severe extensive contracture, leading to nasal and eyelid deformities. (*Above*, *center* and *right*) Full release of the contracture showing fishtailing at the edges and the contour of the neck. (*Below*, *left*) The defect and the anterolateral thigh flap for the neck defect. (*Below*, *center* and *right*) Two-year postoperative photographs show good contour of the neck and lips. Further facial surgery was performed to correct the ectropion and nasal deformity.

Fig. 3. (*Above, left* and *center*) Photographs showing a band-like contracture in the neck. (*Above, right*) Multiple Z-plasties to the neck were used to correct ectropion. (*Below*, *right*) Drawing of the "Z." The corners of the Z are made 90 degrees on the incision and a few millimeters and then extended to the planned end of incision. (*Below*, *left* and *center*) Postoperative photographs showing correction of the neck and lip deformities.

hyoid bone can result in ptosis and herniation of the submandibular gland. A transverse incision placed in the lower third of the neck is most favorable. Fishtailing of the incision is performed at the ends to better release and avoid a linear band at the corners. If the scars are unsightly and if adequate donor area is available, the whole of the scar can be excised. The platysma and all the fibrotic tissues are released until good hyperextension and lateral rotation of the neck are obtained. The bed must be soft and supple.

Skin grafts, dermal substitutes with grafts, and flaps are available for covering the postrelease raw area[25] (Table 3). Grafts help to show up the cervicomental angle and the contour of the neck. Nevertheless, the grafts are not pliable and contract.[25] To a great extent, the use of dermal substitutes offers better outcomes and can provide pinchable skin, although obtaining complete take in large areas would need attention to detail.[26,27] Good results can be obtained if thin perforator flaps can be raised in the individual.[28]

We mainly use intermediate-thickness split skin graft sheets (0.0012 to 0.0014 inch) harvested by a dermatome. When complete take of the graft is obtained and proper aftercare is provided, consistent good results can be obtained. Flaps are used at times when critical structures are exposed. Flaps provide better aesthesis with pliable and supple skin.[24,29,30] If the flaps cannot cover the entire defect, they are used to cover the anterior visible portion of the neck, and the rest of the areas are covered with graft. When grafts are used alone, they are laid transversely and

Table 3. Comparison of Reconstructive Options

Technique	Color Match	Donor Site	Donor Defect	Pros	Cons
Direct closure	+	Not applicable	Nil	Like tissue	Distortion of critical landmarks, stretching and hypertrophy of scar
Z-plasty	+	Limited to nearby normal tissue	Nil	Like tissue, breaks straight line scar	Transverse limb shortening, distortion of critical landmarks
Split-thickness skin graft	Poor	Good amount available, but may be limited in extensive burns	Pigmentation and hypertrophic scar of donor areas	Large donor area available; simple technique	Recurrence of contracture
Full-thickness skin graft	Satisfactory	Limited	Nil	Less contraction, better color match than split-thickness skin graft	Cannot be used to cover large areas; essential to have full take to avoid raw areas
Tissue expansion	Good	Presence of nearby normal tissue is essential	Nil	Like tissue	Time consuming, temporary distortion, multiple stages
Local flaps	Good	Limited	Less likely	Less contraction	Not possible in extensive burns
Regional flaps and free flaps	Good match possible	Limited	Yes	Less contraction	Donor defect, limited options, expertise
Dermal substitute	Variable, according to the quality of skin graft	Not applicable	Nil	Less contraction than a simple skin graft	Expensive, staged procedure

Fig. 4. (*Above*, *left* and *second from left*) Severe postburn contractures of the neck. (*Above*, *second from right*) Status of the full release of the contracture and fishtailing at various sides to enable more grafting to be done. (*Above*, *right*) Raw areas covered with transferred sheaths of skin graft. Note the quilting of graft to the bed to obtain good cervicomental angle. (*Below*, *left*) Full take of the graft. (*Below*, *second from left*, *second from right*, and *right*) Long-term result showing the maintenance of contour and the cervicomental angle.

quilted to contour the shape of the neck (Fig. 4). Absolute hemostasis is essential to obtain complete take of the graft.

We use the quilting technique and a tie-over dressing. The tie-over dressings are replaced with a custom-made splint worn over the dressing after

Table 4. Summary of Treatment Options for Postburn Alopecia of the Scalp

- For scalp alopecia defects away from the hairline, excision and primary closure measuring 15–20% of the scalp with 80–85% normal scalp available for undermining and closure is a viable option. However, this could still result in a hypertrophied scar or induce slow stretching of the scar.
- Burn scars can be covered with a rotation flap, transposition flap, or several banana peel flaps, with 60–70% of the normal scalp available for design and movement of the flaps.
- Burn scars that cover 40–50% of the scalp can be treated using tissue expanders if there is at least 50–60% of normal scalp accessible for expansion.
- Hairless areas involving 50–60% of the scalp with at least 50% normal hair available for donor harvesting can be treated with micrografting. Body hair, particularly beard hair, can cover defects of more than 60%, with chest hair coming in second. Larger portions can also be managed by making a natural hairline at the front, then covering the remainder of the head with a hairpiece or wig. In a scarred bed, the results are suboptimal.
- Follicular unit micrografts can transplant all postburn scars on the scalp, ranging from 15–60%.

the first dressing. Patchy areas of loss of graft if they occur are regrafted. If raw areas are left to heal spontaneously, they lead to the recurrence of the contracture, hypertrophic scars, and poor aesthetic outcome. Raw areas healing by secondary intention delay the institution of physical therapy such as the massage of the graft and compression dressings. After complete healing, compression dressings are used for at least 6 months after surgery. [**See Video (online)**, which demonstrates the principles and technique of postburn neck contracture release in a young woman. The video illustrates the preoperative photograph, critical steps in the release, and postoperative follow-up photographs showing the results.]

Dermal regeneration templates can be used after contracture release,[31,32] and a thin autograft can be applied after 3 weeks. Dermal substitutes are unforgiving and should be placed on a well-vascularized, noninfected bed after perfect hemostasis. After 2 to 3 weeks, the outer protective layer is replaced by a thin autograft. The advantage is that the graft contracture is less, the cervicomental angle is well maintained, and the skin texture is pliable.[26,27,31,32] We preferably use this in children, who tend to form keloids. Because only a thin split skin graft is used with this technique, the risk of keloids in the donor area is reduced.

If microsurgical expertise is available, thin deep inferior epigastric perforator flaps, thin anterolateral thigh flaps, or radial artery forearm flaps can be used.[33,34] These flaps can also be preexpanded so that the area of skin available is greater to produce excellent results.[28] Extensive primary thinning of these flaps may lead to partial necrosis and may need skin grafting. This compromises outcome, and an alternative is to aim at complete survival of the flap and thin the flap subsequently.

The surgical principles of treating postburn contractures in children are the same, but they present some specific challenges. The split-thickness skin graft does not keep pace with the growth of the child and recurrence of contracture is inevitable. The scar management needs to continue for a prolonged duration. It is also difficult to enforce compliance with splints in children.

Scalp

Burns to the scalp may produce alopecia. Scalp alopecia can be treated by hair grafting, serial excision, local flaps, and tissue expansion[35] (Table 4).[35–39] Hair grafting and serial excision are performed for thin strips of alopecia with pliable skin.[36] Hair grafting is best performed to reconstruct the anterior hairline. If the skin is not pliable and elastic, hair grafting may not be a good technique because of the precarious blood supply of the bed.[37] Local flaps such as the scalp rotation and advancement flap, pinwheel flap, and banana flap can cover small to medium defects.[38] Local flaps can have problems such as incisional scars, iatrogenic alopecia, and unnatural direction of hair growth. Tissue expansion is the preferred method to reconstruct the hair-growing areas of the scalp. Expanded adjacent skin can be used to cover medium to large areas of alopecia with poor pliability.[35,36] Tissue expansion provides skin and soft tissue of the same color and texture of the adjacent tissues to provide a pleasing contour (Fig. 5).

If the calvaria is exposed, it is ideal to débride the bone and cover it with a flap.[38] With the advent of microvascular flaps, there is a very minimal role for removing the outer table of the skull or drilling multiple burr holes to allow granulation followed by skin grafting. Such grafting results in a scar adherent to the skull bone and is difficult to excise during secondary reconstruction if the requirement arises.

Forehead

Contractures in the forehead can result in the superior displacement of the eyebrows and difficulty in closing the eyes (Fig. 6). To correct the upward displacement of the eyebrows, we incise along the superior border of the eyebrow, obtain

Fig. 5. (*Above*) Postburn alopecia of the scalp with severe hypertrophic scar on the edges. (*Below*, *left*) Tissue expander applied to the scalp and lower part of the face. (*Below*, *center* and *right*) Six months after removal of the expander.

eyebrow alignment, and cover the area with a full-thickness graft. An alternative is to incise along the anterior hairline, but the severity of scar may cause difficulty in dissection to achieve the desired alignment of the eyebrow. The unyielding frontal bone helps to splint the graft against significant contraction. Tissue expansion can also be done to resurface the defect with skin of similar color and texture.

Eyebrow Reconstruction

Alopecia in the eyebrows is best treated by hair transplantation. The challenge in hair transplantation for eyebrow alopecia in burns is the skin quality in the area.[39] In scarred skin with sufficient pliability and vascularity, hair transplantation offers a simple and less morbid solution for reconstruction.[39,40] During hair transplantation, attention should be given to the direction of the hair during transplantation. Superior eyebrow hair points inferolaterally, inferior hair points superolaterally, and the medial hairs point up.[39] Composite skin-bearing grafts taken from the ipsilateral temporoparietal region offer equivocal outcomes.[40] When vascularity is in doubt, the composite grafting can be staged to add thin strips to increase the height in each stage.[40] In a severely scarred bed, the use of temporal artery–based pedicled flaps offers good long-term outcomes.[41] Male patients have bushy eyebrows and frequently need reconstruction with flaps, and female patients can manage with eyebrow pencils and camouflage.[42,43]

Eyelids

The common sequelae of eyelid burns are ectropion, epiphora, risk of corneal exposure, and exposure keratopathy. The risk of corneal

Fig. 6. (*Above*) Contracture of the forehead causing inability to close the eyelids and ectropion of the upper lip. (*Below*, *left*) Release of the excised scarred tissues and grafting of the raw areas on the upper lip and forehead. (*Below*, *center* and *right*) Postoperative photographs after 6 years, with the child comfortably opening and closing the eyelids.

injury is so real that while we wait for the burn scars to mature in other sites, in eyelid contracture, early correction is advised.[43]

When planning ectropion correction, the face as a whole must be examined. As mentioned earlier, when eyelid contractures are associated with neck contractures, the neck should be addressed first to remove the extrinsic component of the deformity. Usually, both eyelids are affected. Correction of one eyelid at a time is advised. The bed being so mobile, contraction of the graft is bound to occur. To counter the inevitable postoperative secondary contraction, effort is made to put in more graft by mild undermining of the edges. This is difficult if both eyelids are corrected at the same time. The most contracted lid is corrected first, and if both are of the same severity, correction of the upper eyelid takes priority. We prefer to use postauricular full-thickness graft for the lower eyelid and a thick split skin graft for the upper eyelid. Full-thickness skin graft makes it difficult for the upper lid to fold on looking up. Lifting of the upper lid is weight-sensitive, and even a thick graft may contribute to ptosis.

To correct the ectropion, an incision is made close to the eyelid margin without injuring the eyelashes. It is prolonged with a 15-degree upward slope, 15 mm beyond the lateral canthus.[44] A downward slope gives a sad eye.[44] This point is also a factor against performing reconstruction of both lids at the same time. A tie-over dressing is applied to ensure complete take of the graft.

The other deformities are the contracture folds at the medial region and, less often, at the lateral canthal region. In their correction, the aim

is to get the punctum appropriately oriented for the effective function of the tear pump mechanism.[45] Various combinations of Z-plasties such as the five-flap Z plasty or the Mustardé jumping man flap are used.[46]

Segmental loss of eyelids is rare. Up to one-third can be managed by mobilization, canthotomy, and direct suturing. More than one-third of loss should be managed by borrowing from the other lid, which is not usually available in major burns, or by distant flaps. For the lower lid, the Mustardé transposition flap is a good option. Thin flaps from the forehead lined with buccal mucosa or amniotic membrane are used for the upper eyelid. When there is a total loss, thin free flaps such as the dorsalis pedis flap have been used, but unless we have the orbicularis and levator function, they act as cover and fall short of functional reconstructive goals.[43–46]

Nose

The nose stands prominent from the face, with the skin tightly bound to the cartilage framework, with little subcutaneous tissue and fat. In the full-thickness loss of the nose, the challenge is to recreate this complex framework. Local "like tissues" are cheek skin and forehead, and these areas also might be burnt and unavailable, leading the surgeon to distant donor sites transferred as pedicled or free flaps.[47]

Burns over the nose can result in disfiguring hypertrophic scars, difficulty in breathing because of nostril stenosis, alar retraction and cicatrization in the nasal lining, and even complex nasal defects. The most common problem is contracture of the alar rims, causing nasal stenosis.[48] Local flaps or interlacing flap-plasty is a helpful technique to correct nasal stenosis.[49,50]

Alar retraction is caused by scar contracture (alar ectropion), and it can be released to get the ala to normal position, and the raw area can be covered with full-thickness graft.[49] If the nasolabial fold skin is available, it can be folded to act as lining and cover.[50] If there is a full-thickness loss and the largest dimension is less than 1 cm, a composite graft from the ear can be used to reconstruct the ala or columella.[47] Take of the composite graft is dependent on the area of surface contact with the bed. The contact area is increased by taking an extra bit of cartilage, which can be interposed into the nasal skin and edge to edge suturing of the graft.

Larger defects or scarred skin can be reconstructed with a forehead flap[51] (Fig. 7). An expanded forehead flap helps provide thin skin adequate to provide the inner lining and cover with minimal donor-site morbidity.[52] Tissue expansion needs good skin to expand. In burns, the availability of unburnt or scar-free skin is a challenge.[53] The contour of the face is not flat for the base of the tissue expander to drape. The convolutions change the conventional mathematical model of skin availability during planning.

Fig. 7. (*Left*) Scarring of the left side of nose with constricted nostrils and scarring of the forehead. (*Right*) Postoperative photograph showing the use of an expander, and a forehead flap to cover the left side of the nose and a constricted nostril.

If the forehead is not available as a donor area, a thin free flap such as the radial forearm flap can be used as a cover. The defect is first recreated by excising the scarred tissue, and the deficiencies in the cover, support, and lining are assessed separately. For large defects in the lining, the best option would be to use a radial forearm flap with separate islands for the columella, nasal vestibule, and the floor.[54] Separate islands in the radial forearm flap are harvested to prevent centripetal contraction and obstruction in tubed pedicle flaps. Cartilage grafts are incorporated for the columella. Subsequently, multiple stages may be needed to debulk the flap and make it appear well. Walton et al. have described a method in which a computer-generated polypropylene nasal scaffold was prelaminated with a radial forearm flap for the lining and a free temporal fascial flap and skin graft for external cover.[55] When free flaps are not possible, good results can also be achieved using the traditional Tagliacozzi flap, wherein the medial arm skin is brought in as a pedicle flap.[56] Such pedicled flaps can be made thinner than free flaps. A radial forearm flap can also be transferred in an extracorporeal way, similar to the Tagliacozzi cross arm flap.[57,58] For complex nasal defects in older adults and surgically unfit patients, an easier option would be to wear a nasal prosthesis.[59]

Lips and the Oral Commissure

Eversion of the lower lip and microstomia are the two common postburn deformities that occur around the oral cavity. Eversion of the lower lip prevents lip seal, allowing drooling of the saliva, and the exposed mucosa makes an unsightly deformity. Ectropion of the lower lip is also magnified by the contracture of the neck, if any. Circumferential burn causes microstomia and difficulty in feeding.[60] The first step is to correct the extrinsic forces that accentuate the lip deformity. Ectropion of the lip is corrected by an incision at the vermillion margin and releasing it to the full extent. Both lip deformities can be corrected simultaneously, and an intermediate-thickness split skin graft is applied. This is one of the most rewarding postburn operations, both functionally and aesthetically, second only to the correction of ectropion of the eyelids.

Usually, the oral commissure is at the level of a line dropped from the midpupillary line.[61,62] The tight commissure is released laterally, and a V-Y advancement mucosal flap is performed. Commissures must be placed equidistant from the midline to achieve aesthetic outcomes on mouth opening.[62]

Correction of Ear Deformities

The ear is made up of a cartilage framework to which the thin overlying skin is tightly bound. The cartilage gets its nutrition from the overlying skin. This anatomical feature predisposes ear burns to infection, and deformity and also makes subsequent reconstruction a challenge. Mills et al. reported that 52.7 percent of all admitted patients sustained burns in one or both ears.[63] The incidence of complete loss of ear in a series of 100 ear burns was 13 percent.[64]

Planning the reconstruction of a deformed ear would first involve studying the deformity, establishing the loss, and evaluating available skin quality in the vicinity. Of these, the quality of skin in the vicinity determines the reconstructive option and the ultimate result.[65] Marginal and helical losses can be reconstructed with the Antia-Buch chondrocutaneous advancement flap.[66–68] This will make the ear a little smaller, but the outline is maintained. Alternatively, if the postauricular skin is healthy, a thin-tube pedicle flap can be raised in stages and used to form the helical margin. Even without cartilage, the bulk of the flap gives a pleasing contour. Thin flaps are the key to a good outcome, and delay procedures help to raise a thin flap.

Beyond marginal losses, the rest of the ear loss would require a cartilage framework and a well-vascularized soft-tissue cover. Reconstructive options vary with the choice of these two needs. Bhandari[64] classified the total loss of ear deformities into five groups based on the management strategy (Table 5).[65,69]

In all major reconstructions of the ear, the defect is made on a template. Subperichondrial harvest of costal cartilage is performed. Usually, the synchondrosis of the sixth, seventh, and eighth ribs of the contralateral side is taken. If we use a separate sliver of costal cartilage to form the helix, the side does not matter. We then prefer the right side to prevent accidental injury to the heart. In groups 1 and 2, a pocket is made, the cartilage framework is introduced, and ear reconstruction is performed in the standard manner. In group 3, the cartilage framework is attached to the remnant by 4-0 Prolene (Ethicon, Inc., Somerville, N.J.) and draped by temporoparietal fascia. In group 4, the framework is covered by a radial forearm free flap.

When a free flap is needed, prefabrication can be performed for safer outcomes.[70,71] The cartilage framework is buried in the distal part of the forearm in the territory of the radial artery flap, avoiding hairy skin. A subcutaneous pocket is created to make the contours of the cartilage framework

Table 5. Classification of Postburn Ear Deformity[65]

Group	Description	Solution
1	Skin in and around the auricular region is healthy	Postauricular skin can be used for draping cartilage framework
2	Skin in and around the auricular region is either scarred or has been split skin grafted but is soft and supple	Postauricular skin can be used for draping the cartilage either alone or in combination with postauricular fascia
3	Skin in and around the auricular region is not available	Local fascial flaps can be used for draping cartilage framework
4	Neither the skin in and around the auricular region nor the local fascial flap (temporoparietal or postauricular fascial flap) is available for draping	These patients require free (microvascular) flaps for draping cartilage framework
5	Reconstruction is not technically possible, or the patient is not willing to undergo any form of reconstruction	Ear prosthesis[69]

visible. The cartilage graft is allowed to mature for 3 to 6 months. The radial forearm flap is then raised, with the length of the pedicle depending on the location of the recipient vessels. If the pathway to the recipient vessels is severely scarred, a thin band of overlying skin can be harvested for the cover of the vessels during transfer (Fig. 8).

The key to success in all the techniques is to have a well-contoured cartilage framework and a thin skin cover that makes the contour visible.[72] The soft tissues of flaps bunch up, hiding the contours of the graft. The outcome depends on the careful placement of nonstrangulating tie-over sutures or bolsters to drape the skin over the cartilage graft. The last step is the creation of the postauricular sulcus. Often, the thick cartilage graft provides enough relief, and if more prominence is needed, the cartilage is lifted by a postauricular incision, creating a sulcus, and the raw area is covered with a split skin graft. Attempts have been made to substitute the cartilage framework with silicone models or high-density porous polyethylene. However, extrusion rates are high and costal cartilage remains the standard of reconstruction.[73]

The lobule is often pulled down because of contracture, and it is corrected to allow the lateral side to show up well. However, total ear lobule loss is rare, and if present, the cartilage graft by itself is planned in such a way that prominence is created at the site of the ear lobule.

Fig. 8. (*Above*) Severe burn injury with loss of right ear. Planning of the cartilage framework (*above*, *right*). (*Below*, *left* and *center*) The cartilage frame is buried in the subcutaneous level superficial to the fascia with a radial forearm flap harvested along with the tip of the skin to protect the long vascular pedicle. (*Below*, *right*) Postoperative result. Most cases will require some additional procedures to thin the flap.

Basic Postoperative Care

Maintaining the released/corrected posture is the key to success. Grafts take 3 weeks to settle and at least 6 months to mature. In the former period, conforming dressings are used and, later, detachable splints are used to maintain the correction. Grafts need daily massage with moisturizing creams. Compression garments are worn at 4 weeks and continued for at least 6 months. Silicone sheets can be used to line the compression garment. They are most useful to prevent graft margin hypertrophy. The grafted areas are cared for at least for 1 year, until the graft no longer has a propensity to contract.

Future

Skin bioprinting has been studied as a novel approach to reconstruct functional skin tissue. Three-dimensional bioprinting for burn injury reconstruction involves layer-by-layer deposition of cells and scaffolding materials over the injured areas.[74] With three-dimensional bioprinters' increasing speed and resolution, this method may be feasible for in vivo tissue regeneration. Three-dimensional printing can also help customize splints and implants for specific sites and patients.[75] They are yet to come to regular clinical use.

CONCLUSIONS

Although burn contractures can occur even with good primary care, severe deformities inevitably occur with suboptimal primary care, leading to functional, aesthetic, and psychological problems. When contractures do occur, available reconstructive techniques can provide satisfactory outcomes. Attention to detail during planning and execution of the procedures and good aftercare are essential. These procedures can make a tremendous difference in the quality of life of burn survivors.

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