Facial Skin Cancer Reconstruction

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Abstract

Nonmelanoma skin cancers are the most common skin cancers in the United States and the most common malignancies afflicting the head and neck region. Reconstruction of resulting defects has significant aesthetic and functional implications, and plastic surgeons are frequently consulted for reconstruction. Reconstruction can be accomplished via a multitude of approaches spanning the reconstructive ladder, and the approach should be individualized based upon both patient-related and defect-related factors. Here the authors propose a simplified approach to facial reconstruction broken down by aesthetic region.

Keywords

- facial skin cancer
- reconstruction
- scalp
- eyelid
- ear
- cheek
- nose

Nonmelanoma skin cancers (NMSCs) are the most common malignancies in the United States; their incidence continues to rise. A recent analysis estimated that the number of people with at least one procedure for NMSC increased by 14% from 2006 to 2012.[1] These are the most common types of skin cancers afflicting the head and neck region.[2] Surgical excision, either through Mohs or wide local excision, remains the treatment of choice. Reconstruction of resulting defects has significant aesthetic and functional implications; therefore, plastic surgeons are frequently consulted for reconstruction.

Both patient-related and defect-related factors should be considered in the reconstruction of facial defects. The patient should be screened for variables that may provoke complications, including diabetes mellitus, cardiovascular disease, tobacco use, hypertension, and anticoagulant use.[3,4] Patient preferences and expectations should be discussed preoperatively to ensure the patient has an accurate understanding of the procedure as well as realistic expectations.[4] It is imperative to thoroughly examine the defect, noting the location, size, shape, and depth.[3]

Facial anatomy can be divided into aesthetic subunits according to skin quality, thickness, color, texture, and contour.[3] The integrity of these units is maintained by replacing tissue that is similar in these qualities: "like for like."[5] Superior aesthetic outcomes are achieved when the defect and reconstruction are limited to a single aesthetic unit.[4] When multiple subunits are involved, it is optimal to use a combination of grafts and flaps that address each individual subunit separately and place scars at subunit junctions.[5]

Reconstruction can be accomplished by a variety of approaches, and the final decision regarding the surgical procedure should be individualized. Specific considerations regarding the defect in each anatomical region will be outlined here. Our purpose is not to provide a comprehensive outline of all reconstructive options available, but rather to propose a simplified approach to facial reconstruction broken down by aesthetic region.

Scalp

The layers of the scalp include skin, subcutaneous tissue, galea aponeurotica, loose areolar tissue, and pericranium. The rich blood supply to the scalp is derived from the external and internal carotid systems. Main contributors include the supraorbital, supratrochlear, superficial temporal, occipital, and posterior auricular arteries.[6] The scalp's vascular, lymphatic, and nervous systems are located in the subcutaneous tissue superficial to the galea aponeurotica. Therefore, flaps should be elevated in the subgaleal plane to prevent injury to these structures. This will also enhance flap mobility.[4,6]

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Functional considerations of scalp reconstruction include durable coverage and protection of the calvarium. Hair-bearing scalp lacks a comparable donor site, so care should be taken to preserve the normal hairline, when possible.

Feasible options for scalp reconstruction span the entire reconstructive ladder. One should consider the need for preoperative or postoperative radiation, prior surgical incisions, exposed structures, type of malignant neoplasm, hair status, and patient expectations when determining the method of reconstruction.[6] More aggressive neoplasms may be best managed with more basic reconstructions (i.e., secondary intention, skin grafts) to allow for postoperative surveillance.[6] A proposed scalp reconstruction is outlined below (►**Fig. 1**).

Healing via secondary intention offers the advantage of avoiding a procedure. Optimal outcomes are achieved in lighter-skinned, bald patients with small, partial thickness defects.[6] Vacuum-assisted closure devices can expedite healing.[7] Secondary intention healing is frequently complicated by alopecia, contour deformities, color mismatch, telangiectasia formation, and longer healing times that may delay adjuvant therapy.[6]

Primary closure provides an optimal aesthetic outcome. It is typically limited to defects measuring < 3 cm in diameter, although it may be possible with larger defects located in areas of laxity, such as the parietal scalp.[6] When closing a scalp defect primarily, it is imperative to limit tension on the skin closure to minimize iatrogenic alopecia.[8] Tension can be minimized by wide undermining of the surrounding tissues. This is done in the subgaleal plane, and can be enhanced by galeal scoring perpendicular to the vector of advancement.[6,7]

Skin grafts can be utilized to cover medium- to large-sized scalp defects, especially when there is minimal concern for aesthetics. Both split-thickness and full-thickness grafts may be used, but pericranium must be present to provide a medium for graft take.[6] In cases where pericranium is absent, a local pericranial flap can be rotated into a defect and then grafted. Another option includes burring down the outer table of the calvarium to access the diplopic space. This encourages granulation tissue formation upon which a skin graft can be transferred in a delayed fashion.[6] Artificial dermal regeneration templates, such as Integra (Integra LifeSciences Corp.), may provide a more durable wound bed for skin grafting.

Local flaps utilized in scalp reconstruction include advancement, rotation, and transposition flaps. Local flaps are preferred in nonradiated patients when primary closure is not possible.[6] They confer good color and contour match and are associated with less alopecia than many other approaches.[6] Complication rates are reported as low as 3.4%.[9] Flaps should be designed to maintain the hairline and incorporate as much vascularity as possible, incorporating one of the main vascular pedicles.[6,10] Scalp tissue lacks elasticity; therefore, flaps should be designed larger than expected with a wide base.[4,11] Substantial undermining is often necessary to mobilize the flap and surrounding tissue.[6] Galeal layers should be approximated first to allow for tension-free closure and to decrease the risk of alopecia or scar widening.[10]

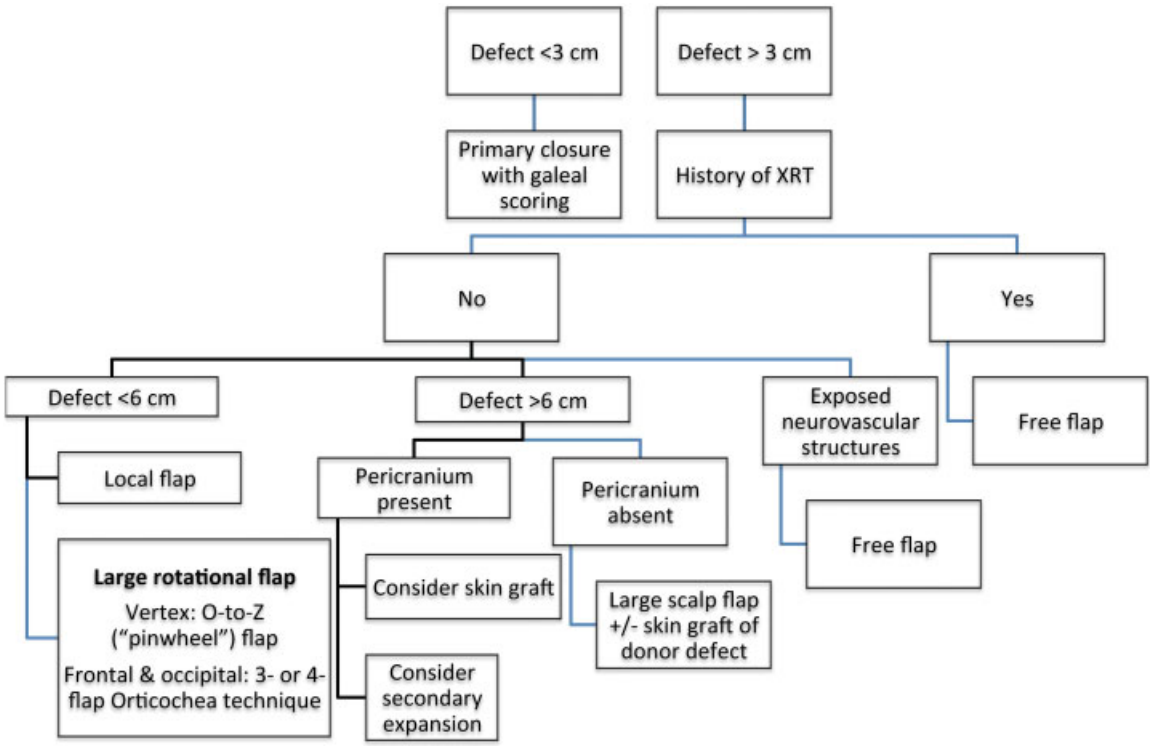

Fig. 1 Algorithm for scalp reconstruction. This represents a simplified approach to scalp reconstruction and not an exhaustive list of reconstructive options. XRT, radiotherapy.

Advancement flaps are of limited utility in scalp reconstruction because of the relative inelasticity of the tissue. They are reserved for small defects of the temporoparietal scalp. Large rotational flaps, however, can be quite useful. Two other local flaps utilized in scalp reconstruction include the O-to-Z, or "pinwheel" flap for small-medium vertex defects (►**Fig. 2**) and the 3- or 4-flap Orticochea technique for medium-large frontal and occipital defects. The disadvantages of these local flaps include long incisions, the need for significant undermining, and the potential distortion of the hairline.[6]

Free tissue transfer is often the best alternative for defects $>$ 6 to 8 cm, exposed neurocranial structures or alloplastic material, and radiated tissue.[6,12] The latissimus dorsi, omentum, anterolateral thigh (ALT), and radial forearm free flaps are commonly used in scalp reconstruction. The optimal flap is broad, flat, and thin. The superficial temporal vessels are the main recipient vessels, so flaps with long vascular pedicles are preferable.[13]

Tissue expansion is a viable alternative to restore hair-bearing tissue in patients with medium-to-large scalp defects too large for local flaps if the wound can be temporized with a skin graft. The patient's wound is initially managed with a split-thickness skin graft. After a period of several months to allow for wound contracture, tissue expanders (TEs) are then placed around the defect. Tissue expansion is most suitable for supple, nonradiated tissue with no history of infection.[6,7,14] The major advantage of tissue expansion is its ability to increase the amount of local, hair-bearing tissue with excellent color match, thickness, texture, and preservation of sensation and adnexal structures.[8] The major drawback is that it involves multiple procedures and has the inherent risk of expander exposure and infection.[6] Although TEs can be unsightly and labor intensive, this is the only method to reproduce large volumes of hair-bearing tissue.

Fig. 2 Example of the double opposing flap for coverage of a parietal scalp defect. The defect is illustrated in (**A**) as well as the flap design. Final closure is depicted in (**B**).

Forehead

The forehead comprises a single facial aesthetic unit but is divided into four reconstructive regions: central, paramedian, temporal, and glabellar. The hairline delineates the superior and lateral borders, while the glabella, eyebrows, and supraorbital rim form the inferior border.[3]

The forehead receives a majority of its vascular supply from the internal carotid artery system. The paired supratrochlear and supraorbital arteries, derivatives of the ophthalmic arteries, supply the central and anterior region of the forehead. Surgeons should be conscious of the course of the facial nerve to preserve the forehead's motor innervation. The nerve travels along Pitanguy's line, which courses 0.5 cm below the tragus to 1.5 cm lateral to the brow. The nerve travels just superficial to the periosteum of the zygomatic arch and then becomes more superficial as it travels cranially just below the superficial temporal fascia. The forehead receives sensory innervation from the supratrochlear and supraorbital nerves as well as the zygomaticotemporal and auriculotemporal nerves.[7] The supraorbital nerve has two main divisions: the superficial branch, which is located superficial to the frontalis muscle, and the deep branch, which travels between the pericranium and the galea.

The goals of forehead reconstruction are both functional—to preserve sensory and motor innervation—and cosmetic—to maintain alignment of the eyebrows and hairline and to minimize scarring.[3] The location of the defect and the vertical, transverse, and anteroposterior skin laxity will influence the reconstructive approach. Reconstructive options include healing by secondary intention, primary closure, skin grafts, local flaps, regional flaps, tissue expansion, and free tissue transfer.[3]

Healing by secondary intention is an option for reconstructing defects located on the concave surfaces of the forehead such as the temporal region. However, healing by secondary intention can be done anywhere on the forehead with reasonable results, as observed in paramedian forehead flap donor sites. Secondary intention requires local wound care and is associated with prolonged healing times. Skin grafts can be transferred to a granulating wound, but they typically have a poor color and texture match.[3]

Primary closure is preferred if adequate tissue is present. Often, defects $<$ 3 cm and located in the central and paramedian portion of the forehead can be closed primarily. Incisions should be designed vertically, when possible, to

avoid displacing the eyebrow and/or the hairline.[3,7] Wide undermining facilitates a tension-free closure.[3,4]

Local flaps, especially rotation and advancement flaps, are also used in forehead reconstruction. Lateral forehead defects can occasionally be managed with superior advancement of cheek and temple tissue.[4,7] Modified advancement flaps such as O-T and A-T flaps are well suited for defects adjacent to the hairline or the eyebrow, as they minimize displacement.[3] Rotation flaps are an alternative for moderate-sized defects of the lateral and paramedian forehead regions.[3] Common problems with local flaps include pincushion deformities, transposition of the eyebrow/hairline, and long curvilinear scars.[3]

Eyelid

The function of the eyelid is to protect and support the globe. Maintaining the delicate balance between functionality and aesthetics in the eyelid is particularly challenging. The eyelids are composed of an anterior and posterior lamella. The anterior lamella is comprised of skin and the underlying orbicularis oculi muscle. The tarsal plate and conjunctiva form the posterior lamella. The tarsal plate is an important source of structural support.[15]

Surgical approaches depend upon the size and location of the defect, lid laxity, the surrounding periorbital tissue, and the abundance of contralateral eyelid tissue.[3,15] Full-thickness, bilamellar defects can be categorized based upon the percentage of lid involvement.

Various types of grafts can be used to reconstruct partial-thickness lid defects. Full-thickness skin grafts are suitable for anterior lamellar defects. Excess skin from the contralateral eyelid is harvested through a blepharoplasty incision and provides the best color and contour match. Posterior lamellar defects can be managed with grafts of the contralateral tarsoconjuctiva, buccal mucosa (in combination with cartilage), hard palate mucoperiosteum, nasal septal mucoperichondrium (with or without cartilage), or auricular cartilage. When designing grafts, oversizing should be avoided to prevent laxity, especially in lower eyelid reconstruction.[15]

Primary closure produces the best functional and aesthetic outcomes and should be attempted for defects involving $<$ 20% of lid width in young patients and $<$ 30% in the elderly with lax lids.[15] Lateral canthotomy or cantholysis can be performed to alleviate excess wound tension or to facilitate closure of defects affecting up to 50% of the lid.[3]

Moderate-sized (30–50% of horizontal lid width) defects of the upper or lower eyelid are preferably reconstructed with Tanzer semicircular rotation flaps. This flap utilizes skin located lateral to the lateral canthus. It is raised in the suborbicularis plane initially, but dissection beyond the orbital rim should proceed in the subcutaneous plane to avoid injury to the zygomatic branch of the facial nerve.[3]

Moderate-to-large (50–100% of horizontal lid width) full-thickness upper-lid defects can be reconstructed with a sliding tarsoconjuctival flap or a Cutler-Beard (bridge) flap. The sliding tarsoconjuctival flap is used for isolated medial or lateral defects. The tarsoconjuctival tissue of the ipsilateral eyelid is advanced horizontally to close the defect. This technique is limited by the amount of tarsal plate available for reconstruction and is complicated by lid margin deformity, lack of cilia, and abnormal lid contour. The Cutler-Beard flap, a lid-sharing procedure, is performed by creating a full-thickness lower lid flap that is subsequently transferred to the upper-eyelid defect. A cartilage graft is often necessary to avoid eyelid contraction or cicatricial entropion.[3]

Moderate-to-large (50–100% of horizontal lid width) full-thickness lower-lid defects can be reconstructed with a tarsoconjunctival flap from the upper lid, known as a Hughes flap (►**Table 1**). Four millimeters of tarsus must be spared to maintain support for the upper lid.[3] This is an extremely valuable technique, but requires two stages.

Other flaps utilized for eyelid reconstruction include the Tripier orbicularis myocutaneous flap and the Mustardé cheek rotation flap. The Tripier flap, a unipedicled or bipedicled flap from the upper lid, is an alternate approach to anterior lamellar defects of the lower eyelid. The Mustardé cheek rotation flap is preferred for combined defects of the lower lid and cheek.[3]

The medial canthal area, housing the lacrimal apparatus, and the tarsoconjuctival sling are important components of normal eyelid function. Often, superficial wounds in the medial canthus heal very well by secondary intention given the concave nature. Reconstruction of deeper defects

Table 1 The Hughes flap: technical pearls

Method of choice for large, full-thickness lower-eyelid defects.
Design upper-lid donor width slightly smaller than actual defect to prevent lower-lid laxity.
Evert the lid over a Desmarres retractor for tension on the lid.
Hydrodissection with local anesthetic can help develop dissection plane.
Must maintain the 4 mm of most inferior upper-lid tarsus for stability.
Levator aponeurosis and Mueller's muscle should be left intact with donor lid.
Can get full-thickness skin graft from contralateral upper lid.
Flap division at 21 days.
At the division stage, leave a few millimeters of extra conjunctiva to line lid margin and prevent corneal irritation.

involving the lacrimal apparatus is beyond the scope of this article and often requires consultation with an oculoplastic surgery colleague.

Commonly encountered complications of eyelid reconstruction include ectropion, scleral show, dry eye, persistent chemosis, excessive tearing, corneal abrasions, and corneal erosions.[3,4] Maintaining lower eyelid and cheek support with canthoplasties and midface lift techniques are of paramount importance to prevent these complications.

Ear

The human ear is a complex three-dimensional (3D) structure composed of varying amounts of cartilage, soft tissue, and skin. The helix–antihelix, concha, and lobule are major surface landmarks.[16] Cartilage is present in the upper two-thirds of the ear; fibrofatty tissue and skin constitute the lower third. The anterior and lateral aspect of the ear lack subcutaneous tissue between the skin and cartilage, resulting in a secure attachment between the skin and perichondrium that limits use of primary closure.[17] The goals of auricular reconstruction are to maintain external auditory canal patency and to restore general shape and projection. The vertical height and complex topography should be addressed secondarily.[17]

The ear is divided into five zones: (1) the helical rim, (2) the superior third of the auricle, (3) the middle third of the auricle, (4) the lower third of the auricle, and (5) the lobule. The location of the defect and the depth of involvement direct the reconstructive approach.[16]

Secondary intention healing and skin grafting are often the most appropriate approach for cutaneous auricular defects. Cutaneous defects < 3 cm in diameter with intact perichondrium are candidates for secondary intention healing.[4] This approach achieves better cosmetic results when applied to wounds on concave surfaces, such as the concha, as the underlying cartilage opposes wound contracture. Secondary intention healing is often avoided for defects of the external auditory canal and helical rim, as wound contracture may produce canal stenosis and contour deformities, respectively.[17]

Cutaneous defects with intact underlying perichondrium are also good candidates for full-thickness skin grafts. Supraclavicular, preauricular, and postauricular skin are acceptable donor sites but must be extensively thinned to replicate the native ear skin. Color mismatch is a frequent problem.[17]

Cutaneous defects violating the underlying perichondrium cannot be treated with skin grafts alone, as bare cartilage lacks the essential vascular supply to support a graft. For defects in areas that do not provide structural support (i.e., conchal bowl), the cartilage can be resected and the graft placed upon the posterior perichondrium. Defects overlying the superior crus, the inferior crus, or the antihelix can be allowed to form a granulation tissue bed that can be skin grafted.[17]

Superficial helical defects are most effectively managed by conversion to composite defects, as skin grafts alone produce unacceptable contour deformity. Helical advancement flaps and wedge/star excisions are mainstays of helical rim reconstruction. Defects < 2 cm are managed with local flaps, including the Antia–Buch helical rim chondrocutaneous advancement flap.[16] Alternatively, a wedge resection with a layered closure can be used for defects $< 15\%$ of auricular height. The "star modification" is used to close larger defects or to minimize lateral protrusion of the ear and cupping deformity.[17] These techniques offer superior cosmetic results but will make the reconstructed ear noticeably smaller than the contralateral normal ear. For defects > 2 cm, a two-stage reconstruction using a postauricular flap with or without cartilage grafts is simple and reliable (►**Fig. 3**).

Small defects of the ear lobule are frequently closed primarily as there is usually excess tissue in older patients.[17] Wedge excisions can also be performed, but a z-plasty or wound edge eversion must be added to prevent notching.[16] A composite graft from the contralateral lobule can be used to reconstruct defects of various sizes. Total lobule loss can be reconstructed with a chondrocutaneous flap including conchal cartilage.[17]

The remainder of the ear is approached in thirds. All have a similar approach. Auricular reduction with Tanzer excision lines effectively manage small composite defects of < 2 cm.[16] Those > 2 cm are ideally reconstructed in layers. The cartilaginous scaffold is replaced with nasal septal cartilage, rib cartilage, or contralateral auricular cartilage grafts. A temporoparietal fascial flap, an excellent choice for upper-third defects because it can be elevated thinly, is then positioned over the cartilage graft. Lastly, a skin graft is placed on the fascial flap. Alternatively, a chondrocutaneous flap from the conchal bowl provides the skin and structural support, while a postauricular flap covers the posterior aspect of the defect. The resulting conchal bowl defect is reconstructed with the postauricular "revolving door" flap. Middle and inferior third defects can be reconstructed this way as well.[17]

Cheek

The cheek is divided into three overlapping aesthetic zones. Zone 1, the suborbital zone, is bound superiorly by the lower eyelid, inferiorly by the gingival sulcus, medially by the nasolabial fold, and laterally by the anterior margin of the sideburn. Zone 2, the preauricular zone, is bound superolaterally by the junction of the cheek and helix, medially by the malar eminence, and inferiorly by the angle of the mandible. Zone 3, the buccomandibular zone, is bound superiorly by the suborbital area, laterally by the preauricular zone, and circumscribes the inferior margin of the lower lip to the midline of the chin. Overall, the contour of the cheek is relatively flat and undergoes significant change with aging, which may assist in disguising scars. The cheek is not a central structure such as the eyelid, nose, or lip; therefore, postoperative cosmesis may be more forgiving.[18]

For all zones, primary closure is best if possible. Vertical closure is preferred as it pushes excess tissue superiorly to minimize any downward tension on the lower lid. Rhomboid or bilobed flaps are used if needed, but can result in pincushioning as well as unsightly scar patterns that violate natural

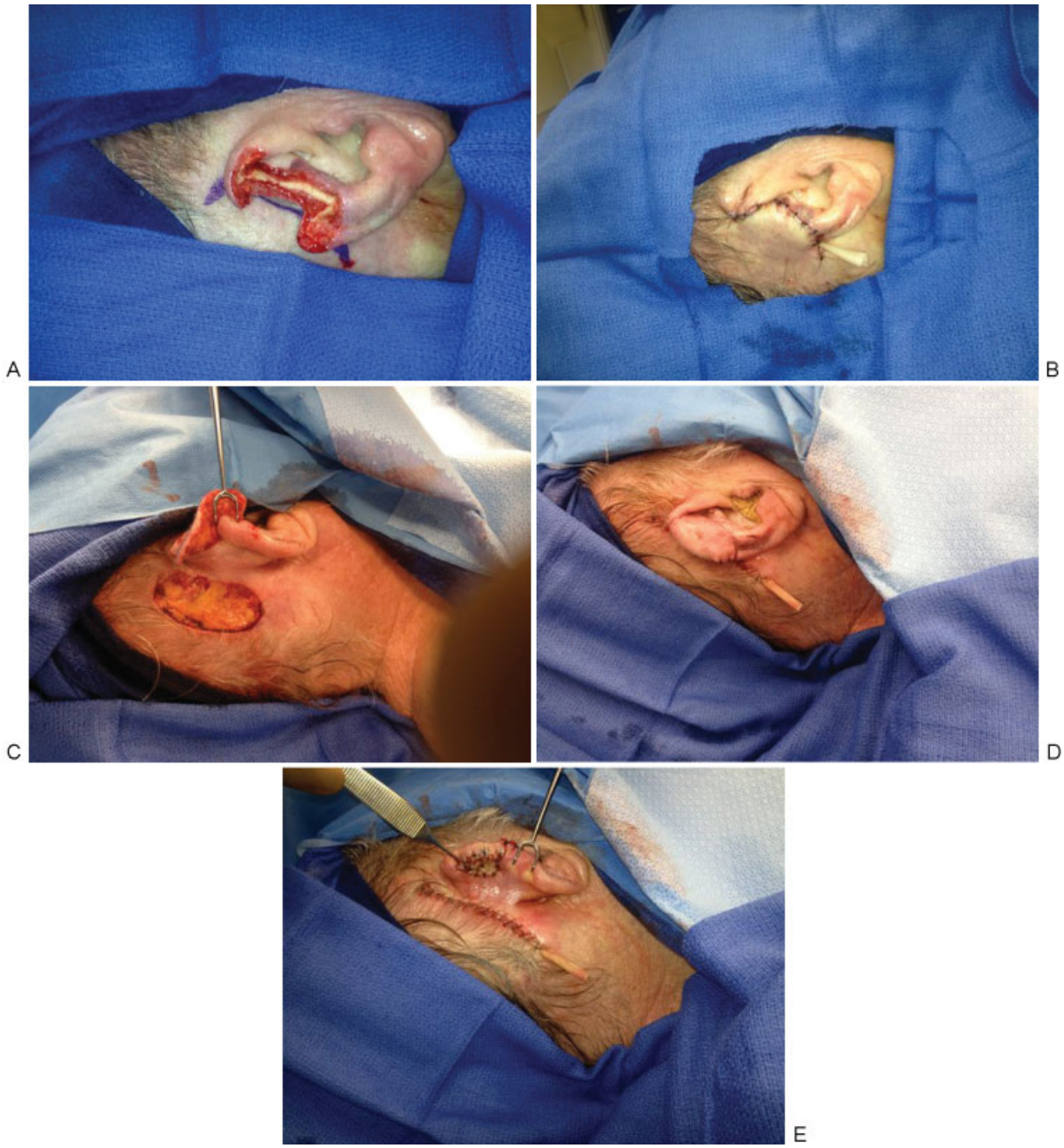

Fig. 3 Example of a postauricular flap for a full-thickness helix and scapha defect. (**A**) The defect outline. The flap inset is shown in (**B**) and division and inset is shown in (**C–E**). A full-thickness skin graft was used to close the posterior auricular defect.

skin tension lines. In general, a longer linear scar from primary closure is better tolerated.

For defects > 3 to 4 cm, a cervicofacial flap is an excellent option for color, texture, and contour match (►**Table 2**). An incision is made at the cheek–eyelid junction and dissection is performed in the subcutaneous plane (►**Fig. 4**). If further mobility is needed for larger defects, a true cervicofacial rotation-advancement flap, which recruits skin from the neck and postauricular areas, can be designed. This is done by extending the incision posteriorly at the level of the lateral canthus to the hairline and then inferiorly at the preauricular crease. The incision then extends posteriorly into the hairline or inferiorly into the neck depending on the desired vector of advancement. Tension is minimized with extensive undermining, which can extend inferiorly to the clavicle. The platysma is divided 4 cm below the mandible. The platysma is then incorporated into the flap to increase vascularity. Postauricular skin can be rotated into the preauricular space for larger defects.

It is important not to place any tension on the lower lid, which can cause distortion and ectropion. This may be avoided by intraoperative canthopexy or anchoring of the flaps to the underlying periosteum. Incisions should be carefully planned in males to avoid displacing the beard or sideburn.[19]

Table 2 The cervicofacial flap: technical pearls

Raised superficial to the superficial musculoaponeurotic system (SMAS) and parotidomasseteric fascia in the face, but deep to the platysma in the neck.
Include upper chest in surgical prep site in case additional recruitment of tissue is required from a cervical or pectoral extension.
At the lower border of the mandible, the subplatysmal plane is entered and one must be wary of the marginal mandibular nerve.
Ectropion can be minimized with anchoring the skin flap to the underlying periosteum.
Incision design: The incision proceeds medially to laterally at the lid–cheek junction; at the lateral canthus, the incision is extended superiorly into the temple, then posteriorly to the hairline, then down the preauricular crease.
Postauricular skin can be incorporated for larger defects.
Inclusion of the external jugular vein can help improve venous outflow.

Fig. 4 Example of the cervicofacial flap for a combined cheek and nose defect. Here the cheek was advanced to the nose–cheek junction and the dorsum was covered with a full-thickness skin graft. (**A**) The defect is shown. Flap elevation is depicted in (**B**). Postoperative outcome is depicted in (**C**) and (**D**).

Free tissue transfer is occasionally needed in patients with very large defects, a history of radiation therapy, or full-thickness buccal defects. Fasciocutaneous flaps, such as the radial or ulnar forearm, lateral arm, or ALT flap, are usually used. The facial vessels are usually the most accessible recipient vessels.

Nose

Reconstruction of the nose is extremely complex. One must consider airway function in addition to its complex aesthetic requirements. The nose is divided into nine subunits, which include the dorsum, the tip, the columella and the paired lateral sidewalls, the alar lobules, and the soft triangles. The subunit principle of nasal reconstruction, described by Burget and Menick,[20] advocates the replacement of the entire subunit if the defect involves greater than half of the subunit. This technique disguises scars by placing them within the border of a subunit.[21] Though the subunit principle is well accepted, some have highlighted the drawback of sacrificing up to 50% of healthy tissue for subunit reconstruction, arguing instead to spare healthy tissue if a scar can be placed strategically at

Table 3 The bilobed flap: technical pearls

Ideal for defect <1.5 cm and at least 0.5 cm above the alar rim.
Make the primary lobe *exactly* the same size as the defect by using a template.
Make the second lobe as wide as the original if there is enough laxity.
Orient the second lobe perpendicular to the alar margin if possible to prevent retraction of the contralateral ala.
Use calipers for exact measurements.
Orient the Burow's triangle a little more superiorly to prevent restriction at the pivot point, and try to place Burow's excision in the alar crease when possible.
Deepen the defect to the perichondrial level and elevate the flap at the perichondrial level.
Make incisions perpendicular to the skin and widely undermine the nose surrounding the defect to help prevent pin-cushioning and alar distortion.

the subunit periphery.[22] The use of strict subunit reconstruction varies by surgeon preference and the needs of the patient. Adherence to the subunit principle in our experience has been most important in convex subunits such as the tip and the ala.

When evaluating defects, one must be systematic. A critical evaluation of the nasal lining, structural support, and the involved aesthetic subunits must be performed. Nasal lining defects that are small and located near the alar rim may be closed with a bipedicled mucosal flap that recruits native lining from the superior vault. For larger defects, typically those > 1.5 cm, either a septal mucoperichondrial flap or a hinge septal flap may be used. The septal mucoperichondrial flap is based on the septal branch of the superior labial artery and pivots on an anteroinferior point near the nasal spine. This flap requires two stages and will obstruct the airway prior to division and inset.[23] The hinge septal composite chondromucosal flap includes cartilage and is ideal for full-thickness defects of the of the dorsum and sidewall.[24] The three-stage folded forehead flap, as popularized by Burget and Menick, is another reliable technique for re-creation of the nasal lining in full-thickness composite defects. Although it adds an additional stage, it is reliable and avoids the need for tedious dissection of intranasal flaps.[23]

Preserving or reinforcing the cartilaginous structure of the nose is important in terms of maintaining nasal shape and preventing contracture and alar notching. If cartilage of the nasal tip, the dorsum, or the columella has been removed during the resection, then it should be reconstructed with grafts prior to soft tissue reconstruction. Ear cartilage is soft and curved, so it works well for the tip and the ala. Defects of the dorsum and the columella require more support, so septum or rib is preferred. Although the normal alar rim contains no native cartilage support, defects of the nasal ala often require cartilage reinforcement in the form of an alar batten graft to prevent alar notching due to scar contracture.[22] Auricular cartilage in this setting is optimal because the contour mimics that of the alar rim, and the donor site is well tolerated.

Once lining and support has been established, the external skin and soft tissue defects can be addressed. Nasal dorsum and sidewall skin is thin and mobile. Often, smaller defects can be closed vertically with excellent cosmesis. Transverse lines of closure are optimal in older patients with ptotic tips. As these subunits are flat with thin skin, full-thickness skin grafts are well tolerated. Larger defects can be closed with rotational flaps, although these are associated with pincushioning and often result in scars that violate the subunit.[22] The banner flap can be used to reconstruct small supratip defects.[22] This flap is designed as a tangent to the longest width of the defect, extending toward the nasal bridge. The dorsal nasal flap, as modified by Rohrich et al, may have less local distortion than the bilobed flap when used for the nasal dorsum and the supratip region.[25] It is useful for central defects < 2 cm in diameter in the distal half of the dorsum with at least 1 cm distance from the alar rim or for defects located above the tip defining points. The pedicle is based ipsilateral to the lesion. Elevation is performed in the submuscular plane, and one must ensure appropriate thickness of the flap for acceptable cosmetic results.

Defects of the nasal tip may be amenable to vertical primary closure in elderly patients with sufficient laxity. This places the standing cutaneous cone (dog ear) in the infratip area and along the dorsum. For defects < 1.5 cm, a bilobed flap is also considered (►**Table 3**). This flap requires precise planning and design as it can be associated with alar retraction and a high degree of pincushioning.[26] The dorsal nasal flap can be utilized for central nasal tip defects up to 2 cm. It is best used for defects at or above the tip defining points. It can be successfully used lower, down to the infratip area in some patients with significant laxity in the dorsum and a ptotic tip who can tolerate a small amount of upward rotation of the tip (►**Fig. 5**). In large or distal defects including the nasal tip, the paramedian forehead flap remains the gold standard, and consists of either a two- or three-stage approach (►**Table 4**). The flap is based on the supratrochlear pedicle 2 cm lateral to the midline, near the medial brow. The flap is elevated in the subcutaneous, subgaleal, and subperiosteal planes as one elevates from distal to proximal. The donor site is then closed primarily when possible. Large donor sites can be left to heal secondarily with acceptable cosmetic results. The main drawbacks are that multiple stages

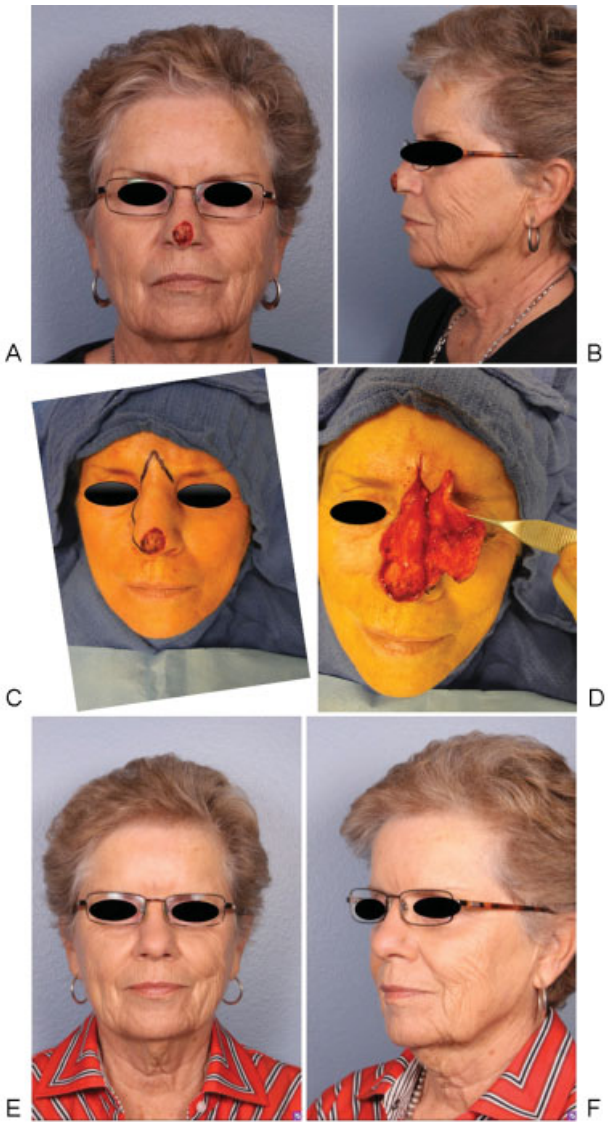

Fig. 5 Example of a dorsonasal flap. Preoperative defect is outlined in (**A, B**). Flap design and elevation are shown in (**C, D**). Postoperative result is depicted in (**E, F**).

are required and the unacceptable cosmesis prior to division and inset.

Alar defects are not optimally closed primarily, given their 3D characteristics. Small, superficial defects $<$ 7 to 8 mm and above the alar margin can be closed with full-thickness skin grafts (►**Fig. 6**). Optimal donor sites in this area include the lateral forehead and conchal bowl. Defects $<$ 1.5 cm that do not involve the alar rim can be closed with a bilobed flap, although this will obliterate the alar groove. For larger or deeper defects, the nasolabial flap is the workhorse (►**Fig. 7**, ►**Table 5**). Older individuals with greater cheek laxity and an already defined nasolabial fold have a particular advantage. A superiorly based flap is designed with the donor scar placed within the nasolabial fold. Following division at 3 to 4 weeks, the donor site is simply excised. As mentioned earlier, these defects almost always need a cartilage graft along the rim to prevent notching and contracture. The subunit principle should be used in the ala given its convex nature. The usual pincushioning of the nasolabial flap is ideal for creating the natural rounded alar shape. Another option for large or full-thickness alar defects is the forehead flap (►**Fig. 8**). This is superior to a nasolabial flap in a younger patient who lacks a defined nasolabial fold.

The smallest of the subunits, the soft triangle, is often the most difficult to recreate. The nasal soft triangle bridges the tip and the nasal ala. Any resultant deformity in this subunit can distort adjacent regions as well. This area is concave in thin-skinned patients and convex with thicker skin, thus reconstruction must be tailored to the individual patient.[23] Although this area is naturally devoid of cartilage, it is prone to notching and requires cartilage reinforcement. Defects involving only the mucosa can be reconstructed with composite grafts from concha. Soft triangle defects that involve only skin with intact lining, can also be reconstructed using composite grafts or nasolabial flaps with cartilage grafts. Full-thickness defects or composite multi-subunit defects are best reconstructed using a paramedian forehead flap that is folded in on itself to provide both internal and external lining. This technique will also require cartilage grafting.[23]

In columella reconstruction, a unilateral or paired nasolabial flap is preferred. In patients with lower cosmetic demands, grafts can be considered.[27] If additional support is required, an anchored columellar strut graft in conjunction with paired nasolabial flaps is optimal. Septal or rib cartilage is preferred to provide longstanding tip projection.[28]

Nasal reconstruction remains a challenging field with a vast array of surgical options. A simplified algorithm for reconstructive options is provided (►**Fig. 9**).

Table 4 The forehead flap: technical pearls

Mark all subunits and then make templates before starting.
Supratrochlear vessel is usually ~2 cm from the midline and 2–3 mm lateral to the vertical glabellar frown lines.
Make pedicle 1.2–1.4 cm wide centered on a Doppler signal of the supratrochlear vessels.
Usually use ipsilateral side of the forehead and rotate medially.
OK to thin the distal part aggressively in smaller flaps and in nonsmokers.
Wait 4 weeks to divide. Allows more aggressive thinning at the time of inset.
Can re-elevate ~70% at the division and inset.
Use 3 stages in large flaps with complex, multisubunit reconstruction, folded flaps, or in smokers.

Fig. 6 Full-thickness skin grafting in a small alar defect. The defect is displayed in (**A**) and her postoperative result is shown in (**B–D**). The donor site was taken from the forehead at the hairline.

Lip

The lip is comprised of four aesthetic subunits. The upper lip has three subunits, including two lateral elements and a central philtrum. It is bound superiorly by the alar grooves and the columella, laterally by the nasolabial fold, and inferiorly by the interlabial gap. The lower lip consists of a single aesthetic subunit bound superiorly by the interlabial gap, laterally by the melolabial grooves, and inferiorly by the mentolabial groove. The vermilion border forms the boundary of the mucosal subunit of the upper and lower lips. Oral competence is the central goal of lip reconstruction and may be achieved by maximizing mobility, sensation, and length of the oral aperture. Lip aesthetics and symmetry are also important factors.[29,30] Approaches to lip reconstruction are based on the depth and size of the primary defect (►**Fig. 10**).

Defects are classified as vermillion only, cutaneous only, or full-thickness. For vermillion defects involving $< 50\%$ of the lip, a mucosal vermillion advancement based on the labial artery or a musculomucosal V-Y advancement may be used. Musculomucosal V-Y advancement results in local volume increase for focal defects. For vermillion defects $> 50\%$, buccal mucosal advancement may be used. This may result in color disparities between native vermillion and is prone to

Table 5 The nasolabial flap: technical pearls

Ideal for the ala and columella reconstruction.
Always do as 2-stage, superiorly based flap.
Mark the medial incision in the nasolabial fold.
Do not extend the incision below the oral commissure.
Do not make the base of the flap any higher than the alar groove.
The distal portion of the flap can be thinned aggressively, but the proximal portion of the flap should not be thinned.
This flap may be unreliable in smokers.

Fig. 7 Example of a nasolabial flap. The defect and flap design is illustrated in (**A**). Postoperative results are shown in (**B–D**).

Fig. 8 The forehead flap. The defect is outlined in (**A**). Ipsilateral flap design is exhibited in photograph (**B**). The patient's postoperative result is depicted in (**C**) and (**D**).

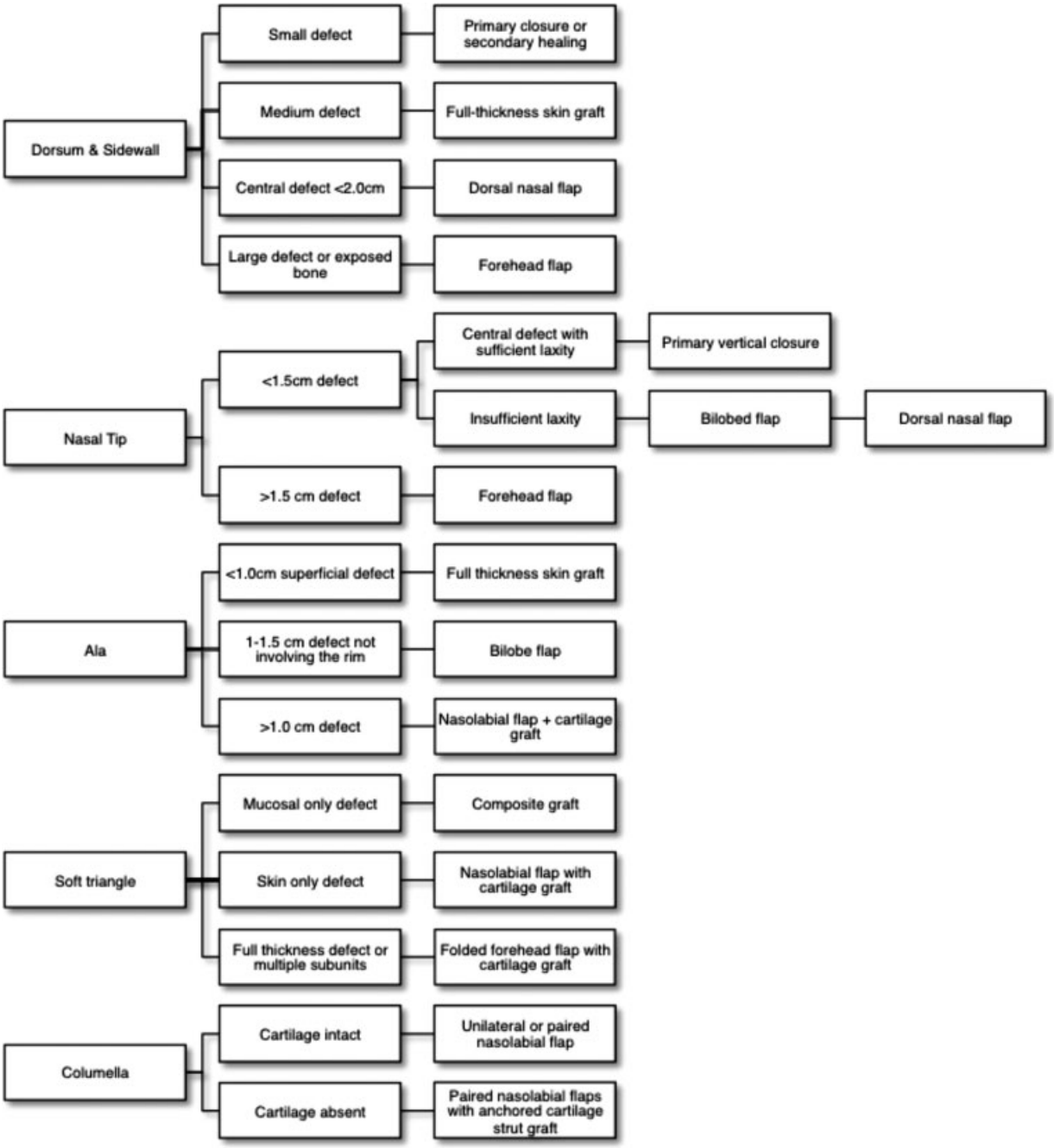

Fig. 9 Proposed reconstructive approach to nasal reconstruction. This represents a simplified approach to scalp reconstruction and not an exhaustive list of reconstructive options.

contracture with resultant lip inversion. Cutaneous-only defects of the upper lip can be challenging; these can be closed with a lateral cheek advancement flap, nasolabial flap, or ergotrid flap (►**Fig. 11**).[31]

Full-thickness defect reconstruction is approached by a rule of thirds. In general, primary closure is advocated for defects less than a third of the total lip length. Defects between one-third and two-thirds of the total lip length are divided into central and lateral defects. Central defects are reconstructed with an Abbe flap with or without perialar crescentic excisions or a Karapandzic flap. The Abbe, or cross-lip, flap is a full-thickness flap based on the labial artery of the opposite lip. A Karapandzic flap is ideal for defects of the central lower lip. In this flap, the orbicularis retains continuity as only the skin and the mucosa are raised. Perioral sensation is preserved, which improves outcomes. Microstomia is a risk directly proportional to the size defect, which may impede nutrition and oral hygiene. This can be treated postoperatively with dilation if needed.

When evaluating lateral lip defects between one-third and two-thirds of the total lip length, the reconstructive approach is determined by whether the oral commissure is

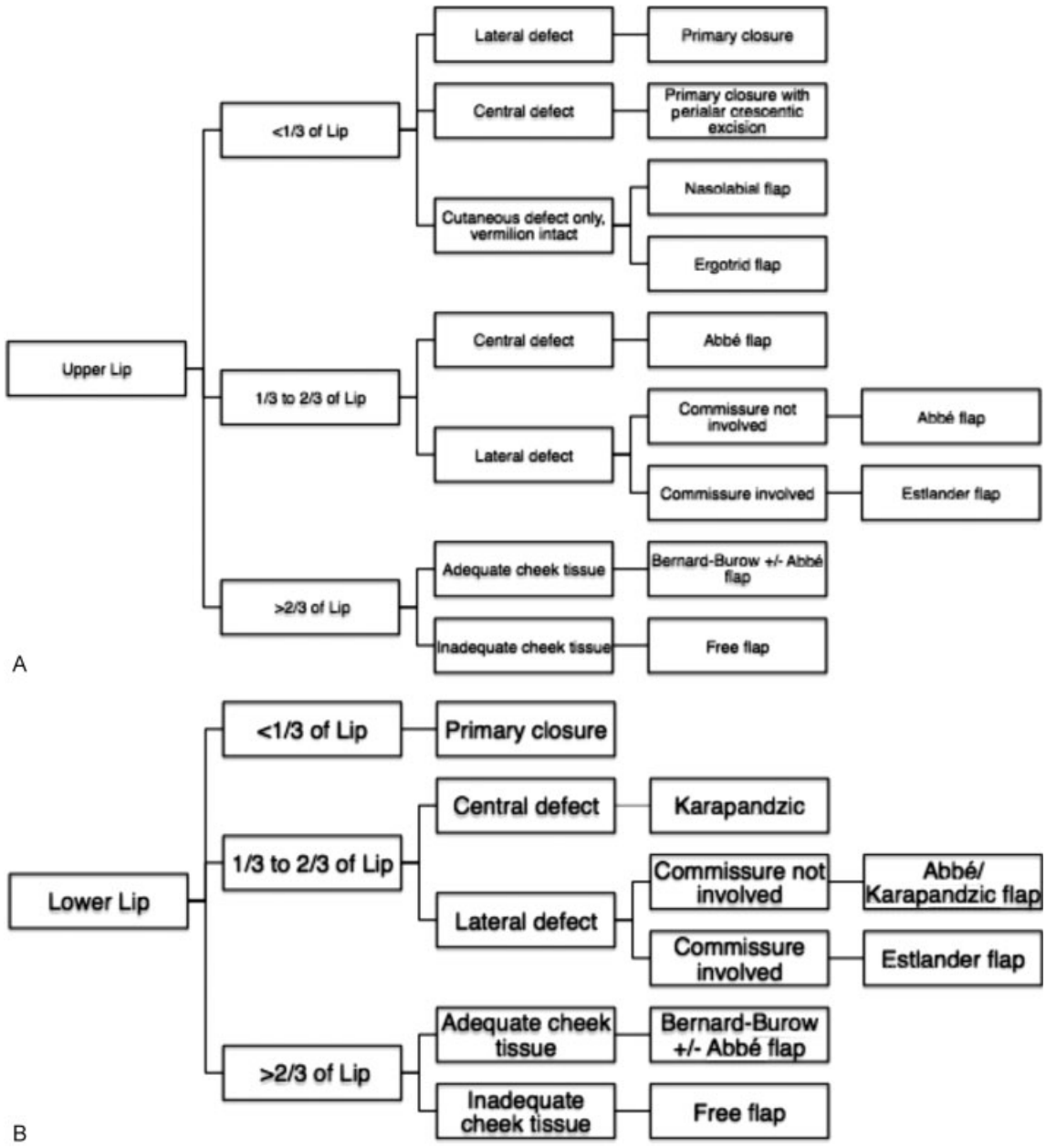

Fig. 10 Full thickness of upper lip (**A**) and lower lip (**B**) reconstruction algorithm by defect size and location. This represents a simplified approach to scalp reconstruction and not an exhaustive list of reconstructive options.

involved. The Estlander flap is optimal for defects that involve the oral commissure. It is a lip-switch procedure that has the advantage of being a single-stage operation. As the modiolus is included in the flap, significant distortion of oral mobility and symmetry may occur and may require a secondary commissuroplasty. In defects without commissure involvement, either an Abbe or Karapandzic flap may be suitable.

Defects $>$ 80% of the lip should be approached by Bernard-Burow cheiloplasty, especially for the lower lip. This technique begins with horizontal incisions from the commissure with Burow's triangles created along the nasolabial fold and labiomental crease to allow for medial advancement of the lateral cheeks. In the Webster modification, mucosa is advanced to create a new lower-lip vermillion. This technique denervates the orbicularis muscle, as opposed to the Karapandzic.

Total lower-lip reconstruction may be performed with a radial forearm and palmaris longus composite free flap. The palmaris longus tendon is attached to the modiolus and serves as a sling. Though sensate recovery may be possible, the major disadvantages include the lack of motor innervation and thus poor oral competence in addition to poor donor color and texture match. These reconstructions tend to descend with time and inevitably have very poor cosmesis.

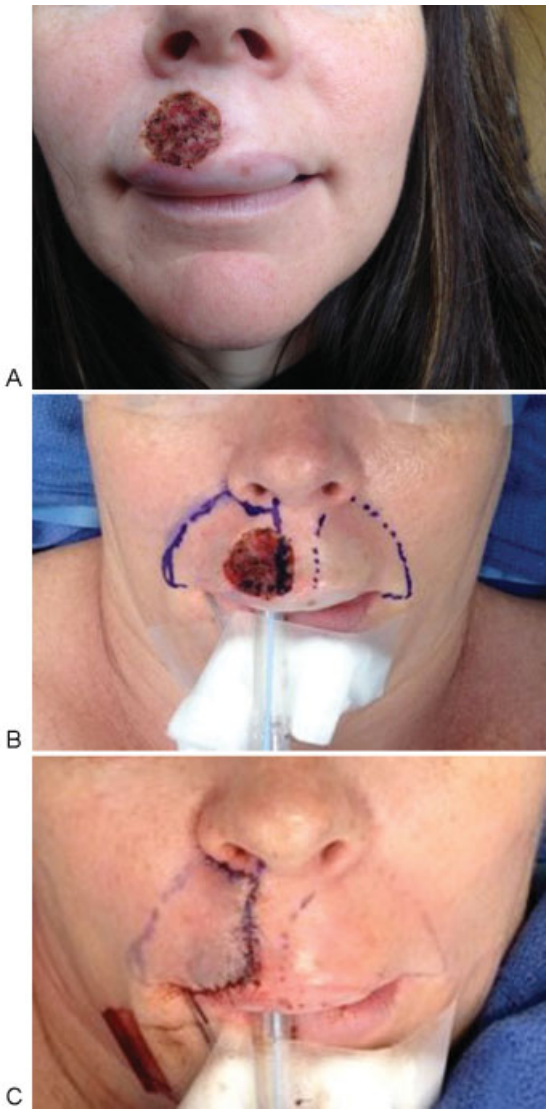

Fig. 11 Closure of a cutaneous only lip defect. Defect is shown in (**A**). The rotational advancement flap design is illustrated in (**B**) and final result is depicted in (**C**).

Chin

The chin is a major aesthetic subunit of the face, although commonly overlooked. It presents a reconstructive challenge due to its limited laxity and general intolerance of skin grafts. Direct closure in a vertical fashion, working the dog ear to the submental area, can provide acceptable results. Alternatively, the defect can be closed horizontally with the scar positioned in the submental crease. For large defects, a submental pedicled perforator V-Y advancement flap may be used.[32]

Conclusions

Reconstruction of facial skin cancer defects embodies the essence of plastic surgery. It focuses on both functional and aesthetic concerns and ranges in techniques from the simplest primary closure to the most complicated free flap reconstructions. When studying this topic, it is easy to become overwhelmed with the multitude of various techniques described. Each surgeon should simplify the problem and develop their own algorithm and armamentarium of techniques to achieve a reliable and reproducible result for each type of defect.

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