Nonmelanoma Facial Skin Cancer: A Review of Diagnostic Strategies, Surgical Treatment, and Reconstructive Techniques

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ABSTRACT: Nonmelanoma skin cancer is the most common form of cancer in the United States, and the face is a common area for skin cancer development due to its frequent exposure to the sun. This article focuses on the surgical management of facial nonmelanoma skin cancers, including diagnostic considerations, biopsy techniques, and staging. In addition, we discuss surgical treatment options, including indications, techniques, outcomes, and facial reconstruction following tumor excision.

KEYWORDS: Nonmelanoma skin cancer, cutaneous squamous cell carcinoma, basal cell carcinoma, Mohs micrographic surgery, facial reconstruction

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Introduction

Nonmelanoma skin cancer is the most common cancer in the United States with an estimated annual incidence of more than 3.5 million.[1] The number of skin cancer cases diagnosed in the United States outnumbers all other cancers combined, and approximately 1 in 5 Americans will develop skin cancer at some point in life.[2] Basal cell carcinoma (BCC) and cutaneous squamous cell carcinoma (cSCC) make up 99% of all nonmelanoma skin cancer (NMSC), with BCC being more common than cSCC.[3,4] Rarer types of NMSC include Merkel cell carcinoma, Kaposi sarcoma, dermatofibrosarcoma, and primary cutaneous B-cell lymphoma.[3] The following article focuses on BCC and cSCC.

The face is a common area for the development of skin cancers given its frequent exposure to ultraviolet (UV) radiation from the sun, which is the main cause of NMSC.[5] While complete eradication of the tumor should be the primary goal in facial skin cancer management, it is also imperative to maximize cosmetic and functional outcomes.[6] The purpose of this review is to discuss the surgical management of facial NMSC, with a focus on diagnostic techniques, staging, excision, and reconstruction.

Review

Types of NMSC

Basal cell carcinoma is derived from keratinocytes in the basal layer of the epidermis, and there is some evidence that the malignant cells arise from immature pluripotent cells of the interfollicular epidermis and the outer root sheath of hair follicles.[7,8] Basal cell carcinoma metastasizes very rarely but may be locally aggressive and invade nearby structures. It has various subtypes that are classified according to their clinical and histopathological characteristics. Noduloulcerative and superficial BCC are the most common subtypes and generally involve the face and neck.[9] Morpheaform, infiltrative, and basosquamous subtypes occur less commonly on the face, but are more locally aggressive than other types of BCC.[9]

Cutaneous squamous cell carcinoma originates from epidermal keratinocytes. The most common cause is cumulative UV exposure, although human papillomavirus (HPV) and human immunodeficiency virus (HIV) infections, burn scars, and chronic inflammatory dermatologic conditions can also lead to cSCC development.[3] Cutaneous squamous cell carcinoma is often locally aggressive and metastasizes to regional lymph nodes more frequently than BCC, although the incidence of regional lymph node involvement in cSCC of the head and neck is just 5%.[10] Development of regional metastasis indicates a poor prognosis for cSCC, with a 5-year overall survival of 25% to 35% and 10-year survival under 20%.[10]

Diagnosis

The first step to diagnosing NMSC is acquiring a detailed history that includes lesion duration, growth rate, and associated symptoms.[2] NMSC is usually a slow growing, locally invasive tumor that erodes or ulcerates. Assessing for NMSC risk factors including a history of sun exposure, sunburns, ionizing radiation exposure, use of tanning beds, HPV infection, or chemical exposures is also important.[2] Information about use of immunosuppressant medications should be obtained, as these increase the incidence of relapse and death in NMSC.[11]

Patients should also be asked about previous or family history of NMSC, as these are both predictors for the development of additional lesions.[2]

A skin examination of the whole body should be performed on patients evaluated for NMSC. Suspicious lesions should be inspected visually and through palpation to assess for induration and attachment to nearby structures.[2] Draining lymph nodes should be evaluated for metastasis, and sites of prior skin cancer should be evaluated for possible recurrence.[2]

There are several noninvasive procedures, which may be used to decide which lesions need to be biopsied, including dermoscopy, confocal microscopy, cross-polarized light, fluorescence photography, and optical coherence tomography.[12] These tools may be used to evaluate lesions before proceeding with formal biopsy. Dermoscopy is the most commonly used of these methods, with a recent survey showing that up to 81% of U.S. dermatologists use the technique in the diagnosis of NMSC.[3,12,13]

Dermoscopy is a noninvasive skin microscopy procedure, which uses a polarized light source and magnifying lens to view abnormalities in the epidermis and papillary dermis.[12,13] It aids in the diagnosis of NMSC through the identification of specific morphological features associated with each subtype type of NMSC, which provides a fast and noninvasive aid to clinical diagnosis.[13] For large lesions on cosmetically sensitive areas of the face, dermoscopy can also be used to identify the most suspicious areas to biopsy.[14] A novel variation of this technique is teledermoscopy, in which dermoscopic images of a skin lesion are captured, typically in a primary care setting, and forwarded to a dermatologist to assist in the management of equivocal lesions.[15] This modality may play a role in decreasing the time to clinical resolution of lesions diagnosed in the primary care setting by facilitating the rapid involvement of dermatologists.[15]

Skin biopsy remains the gold standard for diagnosing NMSC, and possible techniques include punch, shave, and excisional biopsy, with no demonstrated benefit of one technique over another.[16,17] For all techniques, the specimen size and depth should be adequate to provide the recommended clinical and pathologic information for diagnosis and therapeutic decision-making. Repeat biopsy may be considered if the initial specimen is inadequate for accurate diagnosis.[17]

The majority of NMSCs can be managed without diagnostic imaging. However, high-risk NMSCs may invade local structures and cSCC has the potential for distant metastasis; these cases may require diagnostic imaging for optimal management. When there is concern for bony invasion, computed tomography should be employed, while suspicion of soft tissue or perineural involvement requires magnetic resonance imaging.[18]

Sentinel lymph node biopsy (SLNB) is generally not useful for BCC given the very rare chance of metastasis.[3] For cSCC, the value of SLNB is still unclear. An association of positive sentinel lymph nodes and poor prognosis of cutaneous SCC has been demonstrated in several studies, with 5-year survival rates decreasing from around 96% in patients with negative sentinel lymph nodes to 72% in those with positive nodes and adequate treatment and 25% to 35% in patients with positive nodes and no treatment.[3] However, the utility of SLNB is still controversial due to inadequate evidence supporting that it improves survival outcomes. Further research on the effectiveness of SNLB on improving survival in facial cSCC is still necessary to determine its role in the management of this condition.

Staging and risk stratification

The most commonly used risk stratification system for BCC is provided by the National Comprehensive Cancer Network (NCCN) guidelines, which differentiates between tumors at low and high risk for recurrence and metastasis (Table 1).[8,19] This stratification is important for making decisions about surgical versus nonsurgical management of BCC. The tumor-node-metastasis (TNM) classification from the American Joint Committee on Cancer (AJCC) does not apply to patients with BCC because of the low incidence of metastasis.[8]

Unlike BCC, cSCC has a 5% incidence of metastasis, so staging is important for management.[3] The 8th edition of the AJCC includes a staging system for cSCC of the head and neck, shown in Tables 2 and 3.[20] The staging system is most useful for providing prognostic information about outcomes of cSCC. The NCCN clinical practice guidelines for cSCC provide an approach to stratifying tumors at high and low risk for recurrence or metastasis. This stratification, summarized in Table 4, is most useful for guiding management of cSCC rather than providing prognostic information.[17,20]

Surgical treatment

Treatment of both low- and high-risk NMSC is most effectively accomplished through surgery, although recommended surgical modalities differ based on whether a lesion is low or high risk according to NCCN guidelines.[8,17] Therefore, the first step in the treatment planning of NMSC is determining whether a tumor has high or low risk to recur or metastasize. If surgery is not feasible or preferred, nonsurgical approaches including curettage and electrodessication, cryosurgery, topical therapy, photodynamic therapy, or radiation therapy can be considered for low-risk tumors.[8,17] However, patients should be advised that cure rates may be lower for these options compared with surgery.[8,17]

Tumor location is one of the most important factors affecting outcomes of facial NMSC. The NCCN guidelines describe an "area H" of the face, including the central face, eyelids, eyebrows, periorbital skin, nose, lips, chin, mandible, preauricular and postauricular skin/sulci, temple, and ears, where lesions are at high risk of recurrence and metastasis.[6,8,17] According to NCCN guidelines, any NMSC occurring in this area is a

Table 1. National Comprehensive Cancer Network stratification of low- versus high-risk basal cell carcinoma.

	PARAMETERS	LOW RISK	HIGH RISK
Clinical	Location/size	Area L < 20 mm	Area L ⩾ 20 mm
		Area M < 10 mm	Area M ⩾ 10 mm
			Area H
	Borders	Well defined	Poorly defined
	Primary vs recurrent	Primary	Recurrent
	Immunosuppression	No	Yes
	Site of prior radiation therapy	No	Yes
Pathologic	Growth pattern	Nodular, superficial	Aggressive
	Perineural involvement	No	Yes

Area H = "mask areas" of face (central face, eyelids, eyebrows, periorbital, nose, lips [cutaneous and vermilion], chin, mandible, preauricular and postauricular skin/sulci, temple, ear), genitalia, hands, and feet.
Area M = cheeks, forehead, scalp, neck, and pretibia.
Area L = trunk and extremities (excluding hands, nail units, pretibia, ankles, feet).

high-risk lesion requiring surgery. The concept of facial aesthetic units, more commonly used for planning facial reconstruction, may also factor into surgical decision-making when treating NMSC. These units are associated with different NMSC incidence and recurrence rates and may play a role in the evaluation, surgical planning, and follow-up of NMSC.[21,22]

The goal of any surgical procedure used in the treatment of NMSC is to remove the lesion with tumor-free margins. This may be achieved by surgical excision with standard margins or Mohs micrographic surgery (MMS).

Standard surgical excision

Standard surgical excision involves removal of the tumor by relying on clinical margins.[6] According to clinical practice guidelines from the American Academy of Dermatology, standard excision is recommended for low-risk NMSC and should be performed with a 4 to 6 mm margin of uninvolved skin around the lesion to a depth of the mid-subcutaneous adipose tissue with histologic margin assessment.[8,17]

The major benefits of standard surgical excision are a short operating time and minimal need for specialized training or equipment.[6] However, the procedure relies on clinical margins, and re-excision may be required if positive margins are apparent on histopathological sectioning.[6] A systematic review by Lansbury et al[23] found an incomplete excision rate of 8.8% and local recurrence rate of 5.4% following standard excision for the treatment of cSCC, highlighting the drawbacks of this procedure for use on lesions with a high risk for recurrence.

For large or complex defects, reconstruction should be delayed until histological confirmation of tumor-free margins. Staged surgery can also be used when narrow margin excision is used in cases where healthy tissue is crucial for function and cosmetics.[6] Following tumor excision, the wound may be covered with nonadherent surgical dressing until permanent sectioning of the tumor is examined. Reconstruction can be performed with histopathological evidence of tumor-free margins, or subsequent excisions are performed until negative margins are obtained.[6]

Mohs micrographic surgery

The goal of MMS for NMSC is to completely remove the lesion and surrounding margins while sparing as much tissue as possible. The technique was first developed by Dr Mohs in the 1930s for the treatment of NMSC and has since been used for the removal of all types of cutaneous malignancies.[24] The American Academy of Dermatology currently recommends MMS for all high-risk NMSC based on NCCN criteria.[8,17]

MMS is performed by removing a thin margin of tissue circumferentially around and deep to the clinical margins of a skin tumor. The specimen is frozen and sectioned in a cryostat microtome, allowing for quick tissue processing. Sectioning the tissue horizontally allows nearly 100% of the tissue margin to be examined under the microscope, and the process can be repeated until the tumor has negative pathologic margins.[24]

A systematic review by Rowe et al[25] found a 5-year local recurrence rate of 3.1% for primary cSCC treated with MMS. The study also found that MMS had lower recurrence rates compared with standard excision for lesions with high-risk characteristics. Similarly, a randomized controlled trial comparing MMS with standard excision of primary and recurrent facial BCC found a 10-year recurrence rate of 4.4% for primary facial BCC treated with MMS and a lower 10-year recurrence rate after MMS (3.9%) compared with standard excision (13.5%) for recurrent BCC.[26] For these reasons, MMS is recommended for high-risk or recurrent NMSC.

Table 2. American Joint Committee on Cancer classification for staging of cutaneous squamous cell carcinoma of the head and neck, 8th edition.

T	PRIMARY TUMOR
TX	Primary tumor cannot be assessed
Tis	Carcinoma in situ
T1	Tumor smaller than or equal to 2 cm in greatest dimension
T2	Tumor >2 cm but smaller than or equal to 4 cm in greatest dimension
T3	Tumor >4 cm in maximum dimension or minor bone erosion or perineural invasion or deep invasion*
T4	Tumor with gross cortical bone/marrow, skull base invasion, and/or skull base foramen invasion
T4a	Tumor with gross cortical bone/marrow invasion
T4b	Tumor with skull base invasion and/or skull base foramen involvement
CLINICAL N (CN)	
CN	REGIONAL LYMPH NODES
NX	Regional lymph nodes cannot be assessed
N0	No regional lymph node metastasis
N1	Metastasis in a single ipsilateral lymph node ⩽3 cm in greatest dimension and no ENE (–)
N2	Metastasis in a single ipsilateral lymph node >3 cm but not more than 6 cm in greatest dimension and ENE (–); or metastases in multiple ipsilateral lymph nodes, none >6 cm in greatest dimension and ENE (–); or in bilateral or contralateral lymph nodes, none >6 cm in greatest dimension and ENE (–)
N2a	Metastasis in a single ipsilateral lymph node >3 cm but not more than 6 cm in greatest dimension and ENE (–)
N2b	Metastasis in multiple ipsilateral lymph nodes, none >6 cm in greatest dimension and ENE (–)
N2c	Metastasis in bilateral or contralateral lymph nodes, none >6 cm in greatest dimension and ENE (–)
N3	Metastasis in a lymph node >6 cm in greatest dimension and ENE (–); or metastasis in any node(s) with clinically overt ENE (+)
N3a	Metastasis in a lymph node >6 cm in greatest dimension and ENE (–)
N3b	Metastasis in any node(s) with clinically overt ENE (+)
NX	Regional lymph nodes cannot be assessed
N0	No regional lymph node metastasis
PATHOLOGICAL N (PN)	
PN	REGIONAL LYMPH NODES
N1	Metastasis in a single ipsilateral lymph node ⩽3 cm in greatest dimension and ENE (–)
N2	Metastasis in a single ipsilateral lymph node, 3 cm or smaller in greatest dimension and ENE (+) or a single ipsilateral lymph node >3 cm but not more than 6 cm in greatest dimension and ENE (–); or metastases in multiple ipsilateral lymph nodes, none >6 cm in greatest dimension and ENE (–); or in bilateral or contralateral lymph nodes, none >6 cm in greatest dimension and ENE (–)
N2a	Metastasis in a single ipsilateral lymph node, 3 cm or smaller in greatest dimension and ENE (+) or a single ipsilateral lymph node >3 cm but not more than 6 cm in greatest dimension and ENE (–)
N2b	Metastasis in multiple ipsilateral lymph nodes, none >6 cm in greatest dimension and ENE (–)
N2c	Metastasis in bilateral or contralateral lymph node(s), none >6 cm in greatest dimension and ENE (–)
N3	Metastasis in a lymph node >6 cm in greatest dimension and ENE (–); or in a single ipsilateral node >3 cm in greatest dimension and ENE (+); or multiple ipsilateral, contralateral, or bilateral nodes, any with ENE (+); or a single contralateral node of any size and ENE (+)

(Continued)

Table 2. (Continued)

T	PRIMARY TUMOR		
N3a	Metastasis in a lymph node >6 cm in greatest dimension and ENE (–)		
N3b	Metastasis in a single ipsilateral node >3 cm in greatest dimension and ENE (+); or multiple ipsilateral, contralateral, or bilateral nodes, any with ENE (+); or a single contralateral node of any size and ENE (+)		
M	DISTANT METASTASIS	G	HISTOLOGIC GRADE
M0	No distant metastasis	GX	Grade cannot be assessed
M1	Distant metastasis	G1	Well differentiated
		G2	Moderately differentiated
		G3	Poorly differentiated
		G4	Undifferentiated

Abbreviations: ENE, extranodal extension; G, grade; T, tumor; N, node; M, metastasis.

Table 3. American Joint Committee on Cancer prognostic stage groups for cutaneous squamous cell carcinoma, 8th edition.

STAGE GROUP	T	N	M
0	Tis	N0	M0
I	T1	N0	M0
II	T2	N0	M0
III	T3	N0	M0
	T1	N1	M0
	T2	N1	M0
	T3	N1	M0
IV	T1	N2	M0
	T2	N2	M0
	T3	N2	M0
	Any T	N3	M0
	T4	Any N	M0
	Any T	Any N	M1

Abbreviations: T, tumor; N, node; M, metastasis.

As MMS examines 100% of the surgical margin and results in definitive tumor removal, staged surgery is not necessary and reconstruction of the defect can be performed immediately. As the Mohs surgeon also serves as the pathologist, communication problems between the surgeon and pathologist are avoided in MMS.[6] Tissue conservation resulting in a smaller surgical defect is an additional benefit.[27] A limitation of MMS is that tissue blocks are not available for molecular testing or further evaluation of high-risk or unusual features. To overcome this drawback, tumor debulking may be performed prior to MMS, and the tissue may be submitted for molecular testing and histopathologic analysis.[17]

Ex vivo confocal microscopy is a novel imaging technique which allows real-time microscopic examination of skin tissue excised during MMS.[12,28] It has been mainly used as an alternative to histologic examination of frozen sections for control of BCC surgical margins. The confocal microscope produces horizontal images of the different skin layers up to a thickness of 200 μm, allowing fast examination of an entire cutaneous sample in the operating room.[12,28] Based on data from several studies, the technique has excellent sensitivity (88.0%-96.6%) and specificity (89.2%-99.0%) for detecting incomplete or narrow BCC margins.[28–33] For now, the high cost of ex vivo confocal microscopy still limits large scale use of this technique.[28]

Lymph node metastasis

In the setting of palpable regional lymph nodes or abnormal lymph nodes on imaging studies, ultrasound-guided fine needle aspiration or core biopsy is necessary for diagnosis of possible lymph node metastasis.[3] A diagnosis of lymph node metastasis requires excision of the primary tumor and lymphadenectomy, with possible adjuvant radiation therapy and chemotherapy.[17] Although indications for adjuvant radiation therapy can vary by institution and clinician, radiation of the involved nodal region can improve clinical outcomes, particularly if multiple nodes are involved and extracapsular involvement is noted.[34] For stage III and IV cSCC with nodal or distant metastases, adjuvant chemoradiation results in better recurrence-free survival than adjuvant radiation therapy alone.[34] Chemoradiation therapy should also be considered for inoperable disease.[17]

Long-term management

Once NMSC has been diagnosed, office visits to check for new or recurrent lesions should be performed annually.[8,17] During office visits, patients should be counseled regarding the risk for new NMSC as well as melanoma, the need for continuing

Table 4. National Comprehensive Cancer Network stratification of low versus high-risk cutaneous squamous cell carcinoma.

PARAMETERS	LOW RISK	HIGH RISK
Clinical		
Location/size	Area L < 20 mm	Area L ⩾ 20 mm
	Area M < 10 mm	Area M ⩾ 10 mm
		Area H
Borders	Well defined	Poorly defined
Primary vs recurrent	Primary	Recurrent
Immunosuppression	No	Yes
Site of prior radiation therapy or chronic inflammatory process	No	Yes
Rapidly growing tumor	No	Yes
Neurologic symptoms	No	Yes
Pathologic		
Degree of differentiation	Well to moderately differentiated	Poorly differentiated
High-risk histologic subtype	No	Yes
Depth (thickness or Clark level)	<2 mm, or I, II, and III	⩾2 mm or IV and V
Perineural, lymphatic, or vascular involvement	No	Yes

Area H = "mask areas" of face (central face, eyelids, eyebrows, periorbital, nose, lips [cutaneous and vermilion], chin, mandible, preauricular and postauricular skin/sulci, temple, ear), genitalia, hands, and feet.
Area M = cheeks, forehead, scalp, neck, and pretibia.
Area L = trunk and extremities (excluding hands, nail units, pretibia, ankles, feet).

annual office visits, and the benefits of self-screening in detecting new skin tumors while they are small and easily treated. Patients should also be counseled regarding the need for sun protection and routine sunscreen application.[8,17]

Facial Reconstruction

Facial reconstruction is often required after NMSC removal to restore both function and appearance. Successful reconstruction depends on accurate defect analysis and a surgical plan that is individually tailored to the defect size, depth, and location.[9] In addition, flap selection must account for local defect structure involvement including nerves, vessels, muscles, and bone.

In planning facial reconstruction, it is helpful to consider several facial units that are organized according to several guiding principles: skin thickness, color, texture, and contour. Distinct facial aesthetic units include the ear, chin, eyelid, lip, nose, and forehead. Reconstruction of every facial unit is a challenge and should be tailored to the unique characteristics of the defect, patient expectations, and surgeon experience.[35]

Ear

Several general principles may guide reconstruction of the auricle, and successful reconstruction requires restoration of the underlying cartilaginous defect in addition to the overlying soft tissue.[36–38] If the perichondrium remains intact, the wound is a candidate for secondary intention healing, which naturally achieves the best cosmetic results.[39] Full-thickness skin grafts may also be used in these cases, although secondary intention healing is generally the treatment of choice in most patients.[39] Importantly, anterior and superior defects are not suitable for skin grafting due to excessive skin mobility in these regions.[36]

If the perichondrium is absent or severely defective, the remaining cartilage should be removed. Small defects are typically repaired by wedge-shaped full-thickness excision with primary closure, although this will lead to a shortening of the ear relative to preoperative length.[38] To avoid such a distortion and allow for tension-free primary closure, the apex of the wedge resection should extend into the concha and point to the root of the helix.[38,40] A variation of the wedge resection used for slightly larger lesions is a star excision. This method is similar to a wedge resection, but also includes 2 triangles of resection on both sides of the antihelix to distribute tension throughout the auricle and facilitate wound closure.[37,41]

Medium defects can be repaired by a helical advancement flap. This flap was originally designed to repair auricular defects confined to the helical rim and is the primary method of helical reconstruction following excision of NMSC.[36] The flap is detached from both the anterior and posterior surfaces of the helix, and depending on the type of defect, must be mobilized

unilaterally or bilaterally along the helical margin. An important aesthetic principle to consider following reconstruction of such a defect is the overall smaller size of the reconstructed auricle. As such, this technique may be less effective in larger defects; generally, defects of up to 4 cm in length are considered the largest which can be reliably repaired.[36,38]

Larger defects can be repaired with a postauricular advancement flap. The postauricular advancement technique has been used for decades and preserves the proper conchal shape, producing excellent postoperative results for large defects. The flap is outlined behind the defect and includes postauricular skin, subcutaneous tissue, and muscle. Preservation of the posterior auricular artery may generate better results but is not necessary for flap survival.[42] The flap provides reliable skin color matching, a similar responsiveness to sun exposure as the native surrounding tissue, good contour, and a reliable vascular supply.[42,43] In cases of very large defects or prior failed reconstruction, a total auriculectomy may also be considered, followed by total auricular reconstruction. This method frequently yields satisfactory results for both the patient and physician.[37,38]

Although less commonly performed, an anterolateral thigh (ALT) free flap and masseter nerve transfer may be used to repair extensive periauricular defects when local advancement flaps are insufficient.[44] Tumor ablation in the periauricular area can result in an extensive soft tissue defect, which may include facial nerve sacrifice. Reconstructive goals include restoration of facial nerve function, wound closure, and maintenance of facial and neck contours. The ALT free flap provides a very reliable and well-vascularized tissue and may be designed as a fasciocutaneous, adipofascial, or chimeric flap to meet the needs of the defect.[45] Nerve transfers, meanwhile, provide a source of healthy axons that may be used for coaptation with the damaged facial nerve.[44] The masseter nerve has recently increased in popularity as the donor nerve for facial nerve reconstruction due to its consistent anatomy, strength of motor impulses, and fast recovery of muscle tone and motion. The masseter nerve transfer is also associated with very low donor-site morbidity, which makes it an ideal choice for the treatment of both small and large facial defects. Once a tumor is resected and the flap is tailored to the defect, the masseter nerve may be anastomosed to the facial nerve branch of the zygomaticus major muscle in cases of facial nerve palsy.[44]

Chin

The chin poses a reconstructive challenge due to its intolerance of skin grafts. As such, direct vertical or horizontal closure provides the best functional results.[46] For chin defects less than 4 cm, the O-to-Z flap is a simple technique that provides satisfactory functional and cosmetic outcomes to the patient.[47] Large defects of 5 cm or greater are often closed with a submental pedicled perforator V-Y advancement flap, although aesthetic results are suboptimal with this technique.[48] Another commonly used option for large chin defects is the laterally based platysma flap, although better aesthetic results come at the price of significant donor-site morbidity.[49]

Eyelid

Various reconstructive techniques exist depending on the size, location, and thickness of an eyelid defect. Importantly, the gray line is a well-known surface anatomic landmark used in the repair of defects involving the lid margin, and care must be taken to align the gray line of separated lid margins in both primary closure and with the use of local rotation flaps.[50,51] Primary closure produces the best aesthetic and functional outcomes and should always be attempted in defects that are less than 20% of the eyelid horizontal width in younger patients or less than 30% in older patients.[52] Moderately sized defects that are 30% to 50% of the horizontal width of the eyelid are often reconstructed with the Tanzer semicircular rotation flap, which uses the skin located directly lateral to the canthus. Care should be taken in dissection of the flap to avoid damaging the zygomatic branch of the facial nerve.[52]

For defects greater than 50% of the horizontal width of the eyelid, the most commonly used flaps are the retroauricular and the Cutler-Beard flaps. These may also be used for moderately sized defects that could not use the Tanzer semicircular rotation flap.[52] The Cutler-Beard flap is prepared from the inferior eyelid below the tars to match the superior eyelid defect.[53] The Hughes procedure, also known as the tarsoconjunctival flap advancement technique, may also be used for full-thickness large defects of the lower eyelid.[54]

Lip

Surgical correction of the lip involves several anatomic considerations including coverage of the external skin, intraoral mucosal coverage, and restoration of sphincteric function.[55] Lip aesthetics, symmetry, and mobility are all important factors to consider.[46] Vermillion zone defects can be repaired primarily or with a mucosal vermillion advancement technique, and it is critical to carefully reapproximate the vermilion border to achieve optimal aesthetic outcomes.[46,56] Cutaneous defects, meanwhile, can be closed with a lateral cheek advancement flap, nasolabial flap, or ergotrid flap.[46,56]

Full-thickness defects require attention to the vermillion, cutaneous, mucosal, and sphincteric aspects of the lips and may be reconstructed with an Abbe flap, Karapandzic flap, Estlander flap, or Bernard-Burow flap.[46] The Abbe flap is a full-thickness flap that relies on the labial artery of the noninjured lip and may be used for central and lateral lip defects.[46,57] The Karapandzic flap, which involves raising only skin and mucosa with a curvilinear incision toward the alar base, maintains orbicularis continuity and is commonly used for defects of the central lower lip.[46] The cross-lip Estlander flap based on the labial artery is performed as a single-stage operation and is frequently used for oral commissure defects.[46,57] Finally, defects

greater than 80% of the lip can use the Bernard-Burow flap technique for medial advancement of the lateral cheeks.[46] The Webster modification of this flap involves also advancing the mucosa to create a new lower vermillion.[46]

Total lower lip reconstruction can be performed using either a bilobed platysma myocutaneous flap, nasolabial flap, submental flap, or the palmaris longus composite free flap.[55,56] The bilobed platysma flap is a relatively new technique that allows for reconstruction of the oral sphincter with a submandibular artery-based flap.[58] Use of the platysma muscle has the advantages of providing a skin texture and color match and is particularly useful in older patients with excess neck skin.[58] Total upper lip reconstruction and restoration of the columella can be achieved with a nasolabial flap or submental flap.[56]

Nose

Reconstructing the nose is an aesthetic challenge due to the alternating concave and convex surfaces, which are divided into subunits and separated from one another by depressions and elevations of the skin. For optimal aesthetic outcomes, it is generally necessary to replace an entire subunit if greater than 50% of the subunit is involved. In addition, the scars from flaps should always be placed within the normal depressions and elevations of the nose.[59] Together, this technique is known as the subunit principle and is especially important in reconstruction of convex surfaces of the nose. For defects involving nasal cartilage, restoration of the nasal framework is crucial to maintaining nasal projection and definition. In these cases, autologous transfer of septal, auricular, or costal cartilage should be performed.[60] Preserving or reinforcing the cartilaginous structure of the nose is extremely important to maintain nasal shape and should be performed prior to any soft tissue repair.

When reconstructing the nasal dorsum, smaller defects can often be closed with vertical primary closure or full-thickness skin grafts, while larger defects may be closed with a bilobed or dorsal nasal flap.[46] The dorsal nasal flap involves rotational advancement of the dorsal nasal skin from the upper two-thirds of the nose and glabella to the lower nose and may have less local distortion than the bilobed flap when used in this area.[46,61] Similar principles apply to the nasal tip, such that small defects may be closed primarily, while the bilobed and dorsal nasal flaps can also be used for small tip defects less than 1.5 cm, which are not amenable to primary closure. Larger defects of the nasal tip may be repaired with the paramedian forehead flap.[46]

Several flaps exist for the reconstruction of the lower sidewall, and surgeons must consider the various options available due to the complexity of this aesthetic subunit.[62,63] These include the nasal sidewall rotation flap, as well as the nasolabial flap, bilobed flap, and facial artery perforator flap, with the latter usually reserved for more advanced defects.[64,65] Figure 1 demonstrates the use of a bilobed flap for a lower sidewall defect.

Small, superficial defects of the ala above the alar margin can often be closed with full-thickness skin grafts, and the nasolabial flap is the flap of choice for slightly larger skin-only nasal ala defects less than 2 cm in diameter.[60,66] The levator anguli oris muscle flap, meanwhile, can be used in the closure of full-thickness defects in this area. The flap permits reconstruction of both the mucosal surface and nasal skin, which maximizes aesthetic appearance with minimal donor-site scarring.[59]

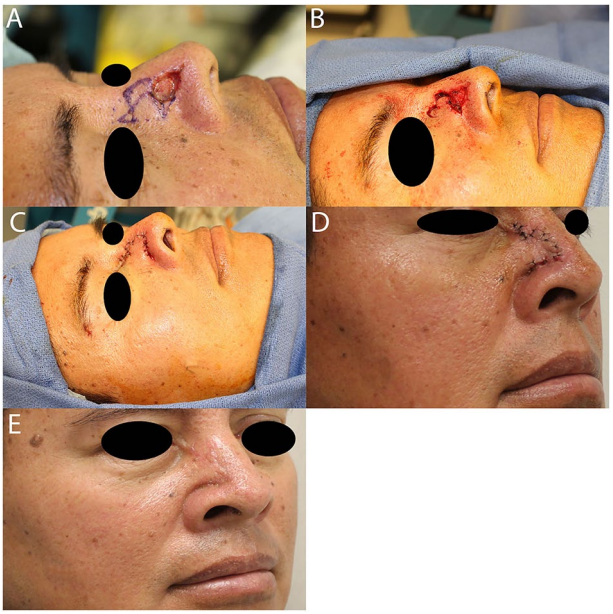

Figure 1. Example of a bilobed nasal flap used in the coverage of a small cutaneous defect. (A) Outline of the flap is drawn adjacent to the soft tissue defect. (B) The elevated bilobed flap. (C) The bilobed flap after inset. (D) The flap 2 weeks postoperatively. (E) Three months postoperatively, the surgical site has healed with minimal scarring and good aesthetic results have been achieved.

The smallest subunit of the nose is the soft triangle, which bridges the tip and ala of the nose, and is often the most difficult to reconstruct. Soft triangle defects that involve only skin with intact lining can be reconstructed using composite grafts or nasolabial flaps with cartilage grafts. Full-thickness defects are best reconstructed using a paramedian forehead flap.[46] Finally, reconstruction of the columella typically requires unilateral or bilateral nasolabial flaps.[46] Septal or rib cartilage is often used in columella reconstruction to provide long-standing tip projection.

Very large cutaneous defects that encompass more than one nasal subunit are most often reconstructed using the paramedian forehead flap.[59] Advantages of this flap are a single donor site for skin and bone that can close primarily with minimal donor-site morbidity and good color match for facial skin.[66] Figure 2 illustrates the use of a paramedian forehead flap for a large nasal defect. The nasolabial, bilobed, or facial artery perforator flap can also be used for reconstruction of extensive defects that involve the lower sidewall, as previously mentioned.[65]

Forehead

When considering forehead reconstruction, healing by primary intention is the preferred option. If this is not possible, the next

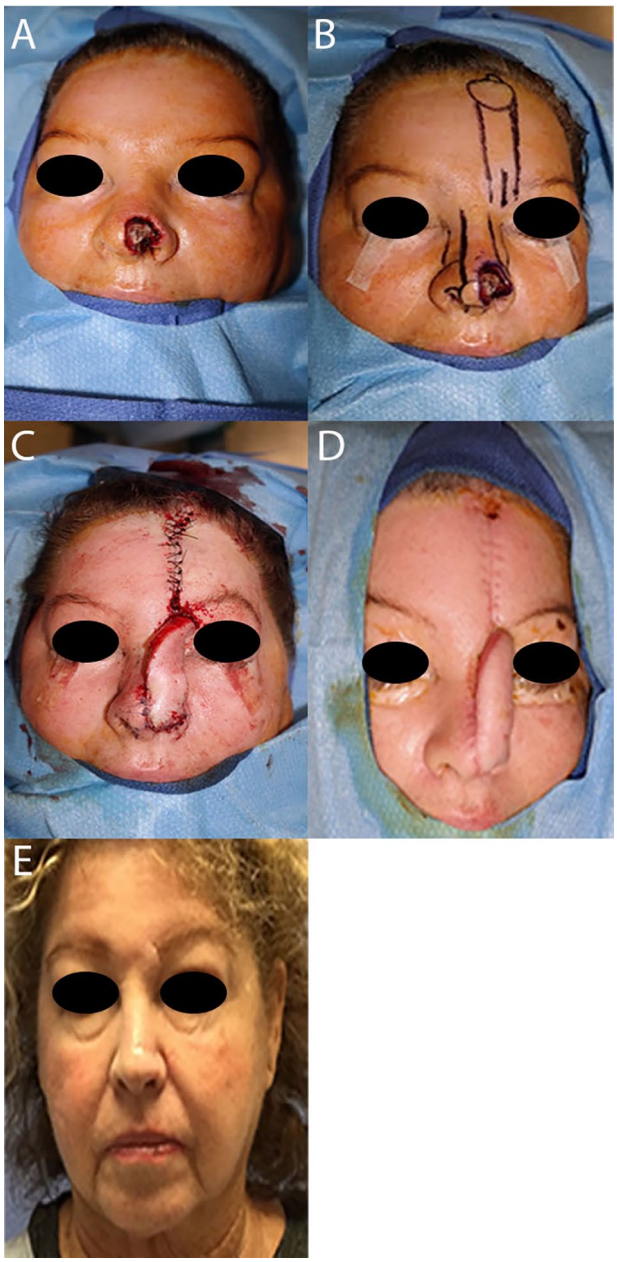

Figure 2. Example of a paramedian forehead flap used in the coverage of a large cutaneous nasal defect. (A) The surgical defect before flap placement, which encompasses several nasal subunits. (B) Outlines of the planned flap and recipient site are drawn. (C) The paramedian forehead flap after placement. (D) Preoperative photograph of the paramedian forehead flap just before division of the pedicle. (E) Two months postoperatively, the surgical site has healed with good aesthetic results.

best choice is a Burow advancement flap, and if necessary, a rotation flap or A-to-T flap can be used for larger defects.[63,67] Burow advancement flap is a commonly performed and versatile reconstruction technique because it provides an excellent method for repair of large defects in proximity to free margins, including the eyebrows and temple.[68] The deep-plane cervicofacial advancement flap has also been successfully used for reconstruction of temple and forehead soft tissue defects and is particularly useful because of its thin size.[69] The periglabellar advancement flap is another option that may be applied to central forehead defects ranging from 2 to 5 cm in size and offers the advantages of using local tissue while hiding scars within natural forehead wrinkles.[70] For extensive defects necessitating free flaps, thin fasciocutaneous flaps such as the radial forearm or lateral arm flaps are frequently used as forehead skin is much thinner than nearby scalp skin.[71]

Conclusions

Facial skin cancer is among the most common of human malignancies. Surgery is the treatment of choice for facial NMSC, and the decision to perform standard tumor excision or MMS depends on tumor location, risk for recurrence or metastasis, and patient preference. The AJCC staging system and NCCN guidelines should be used to determine the optimal treatment modality and obtain prognostic information for facial skin cancers. Following tumor excision, facial reconstruction is often challenging, yet many techniques are available for restoring native anatomy and achieving optimal aesthetic outcomes. In general, reconstructive strategies should be patient-centered and tailored to the defect size, depth, location, and involved structures. Finally, patient expectations should be realistically set to leave both the patient and surgeon satisfied with the aesthetic results.

Author Contributions

IB, DJG and KMP were the initiators of the project. IB, OS and CGL performed the literature review and wrote the first draft of the manuscript, while DJG and KMP performed thorough review and editing of the manuscript. All authors approved the final version of the manuscript submitted for publication.

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