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REVIEW ARTICLE

Reconstructive

Treatment of Non-melanoma Skin Cancers in the Absence of Mohs Micrographic Surgery

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Summary: Non-melanoma skin cancers are the most common malignancies globally. Although non-melanoma skin cancers exhibit low metastatic potential, they can be locally destructive, necessitating complex excisions and reconstructions. Mohs micrographic surgery is the gold-standard treatment for high-risk non-melanoma skin cancers in patients who are appropriate surgical candidates. Despite its efficacy, Mohs micrographic surgery is not readily available in most geographic regions, necessitating that plastic surgeons be well-versed in alternative treatment modalities for non-melanoma skin cancer. Herein, we will discuss the management of non-melanoma skin cancers in settings where Mohs micrographic surgery is not readily available. *(Plast Reconstr Surg Glob Open 2020;8:e3300; doi: 10.1097/GOX.0000000000003300; Published online 22 December 2020.)*

INTRODUCTION

Non-melanoma skin cancers are the most common malignancies in the United States, with over 3 million diagnoses made annually.[1] The annual incidence of non-melanoma skin cancer has increased over the past several decades, with a 35% increase observed from 2006 to 2012 alone.[1,2] This trend is expected to continue secondary to the global rise in life expectancy, improved screening protocols, and the ever-increasing popularity of tanning.[3] The 2 major groups of non-melanoma skin cancer include squamous cell carcinomas and basal cell carcinomas, with the latter being 2–4 times more common than the prior.[3,4] Compared with other malignancies, non-melanoma skin cancers exhibit low metastatic potential and are typically associated with a favorable prognosis.[5] While their metastatic potential is limited, these malignancies can be highly destructive to local tissue, necessitating that some patients undergo complex excisional and reconstructive procedures. Because of this, it is imperative that plastic surgeons be familiar with the management of non-melanoma skin cancers to provide optimal care for their patients.

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Mohs micrographic surgery is the gold-standard treatment for high-risk non-melanoma skin cancers in patients who are appropriate surgical candidates.[6–8] Unfortunately, this procedure may not be available due to medical, financial, or geographic constraints. This article will serve as an overview for the management of non-melanoma skin cancers in settings where Mohs micrographic surgery may not be available.

DIAGNOSIS AND STAGING

Before performing a biopsy of a suspected lesion, the surgeon should take a thorough medical history and perform a physical examination. When collecting a medical history, the surgeon should assess a patient's risk factors for tumor development and potential for metastatic spread. On examination, it is important to assess the size of the lesion and to palpate draining lymph nodes for any signs of nodal metastases.[8] After collecting a thorough history and physical, the surgeon should then perform a punch biopsy of the lesion. Punch biopsy techniques are the gold standard for diagnosing non-melanoma skin cancers, though negative pathology reports do not necessarily rule out malignancy. This is because punch biopsy techniques are associated with false-negative rates, ranging from 6% to 19%.[9–11] To minimize the risk of a false negative result, providers should ensure that the biopsy is 3 mm in width and deep enough to include the reticular dermis.[6,7,9,12] If the sample comes back positive for non-melanoma skin cancer, the surgeon must differentiate whether it is a high-risk tumor or a low-risk tumor.

The National Comprehensive Cancer Network has developed guidelines for determining the level of risk of a non-melanoma skin cancer (Table 1).[6,7] These guidelines

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Table 1. Differentiating Low-risk and High-risk Basal and Squamous Cell Carcinoma based on Guidelines from the National Comprehensive Cancer Network*

Characteristic	Low-risk	High-risk
Location		
Trunk and extremities	Any lesion < 20 mm	Any lesion ≥ 20 mm
Scalp, forehead, cheeks, neck, pretibia	Any lesion < 10 mm	Any lesion ≥ 10 mm
Mask area† of the face, genitalia, hands, feet	N/A	Any sized lesion
Borders	Well-defined	Poorly defined
Primary versus recurrent	Primary	Recurrent
Immunosuppression	No	Yes
Site of prior radiation therapy	No	Yes
Perineural involvement/ neurologic symptoms	No	Yes
Aggressive histologic subtype‡	No	Yes
Unique to squamous cell carcinoma		
Chronic inflammatory process	No	Yes
Rapidly growing tumors	No	Yes
Poorly differentiated	No	Yes
Depth ≥ 2 mm	No	Yes
Clark level IV or V	No	Yes
Lymphovascular invasion	No	Yes

*National Comprehensive Cancer Network. National clinical practice guidelines in oncology: Squamous cell skin cancer. Available at: https://www.nccn.org/professionals/physician_gls/pdf/squamous.pdf. Accessed April 28th, 2020; and National Comprehensive Cancer Network. National clinical practice guidelines in oncology: Basal cell skin cancer. https://www.nccn.org/professionals/physician_gls/pdf/nmsc.pdf. Accessed April 28th, 2020.

†Mask area of the face refers to the central face, eyelids, eyebrows, periorbital region, nose, lips, chin, mandible, ear, preauricular/postauricular areas, and temple.

‡Aggressive histologic subtypes for basal cell carcinoma include morpheaform, basosquamous, sclerosing, mixed infiltrative, or micronodular. Aggressive histologic subtypes for squamous cell carcinoma include adenoid (acantholytic), adenosquamous, desmoplastic (showing mucin production), or metaplastic (carcinosarcomatous).

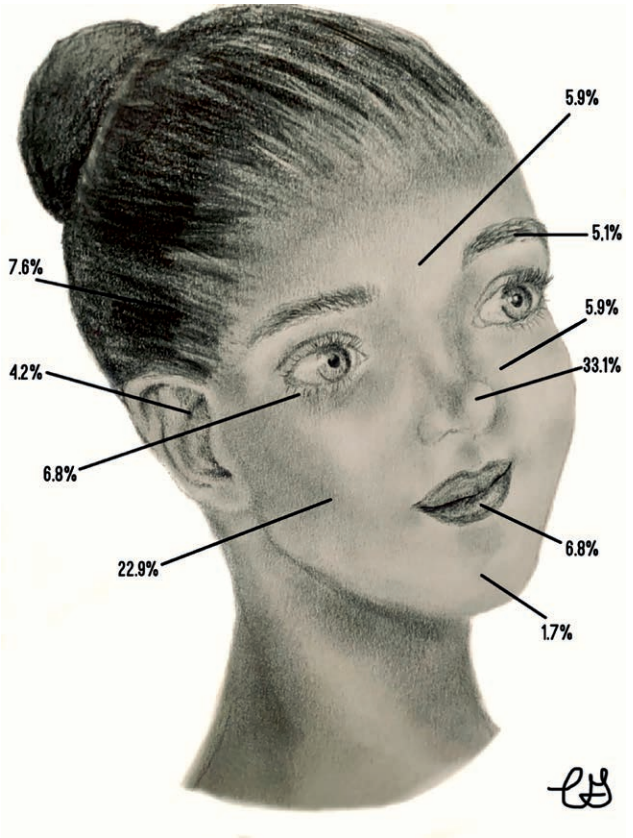

Fig. 1. Incidence of non-melanoma skin cancers of the face.

take into account both the physical properties of the tumor and the patient's medical history. The face is an anatomic region of high clinical importance for plastic surgeons in particular (Fig. 1). Tumors of the face are deemed high-risk due to their high rates of recurrence and their tendency to extensively invade local tissue.[13,14] While both squamous cell carcinomas and basal cell carcinomas have multiple histologic subtypes of varying risks, squamous cell carcinomas, in general, are associated with higher rates of recurrence, metastasis, and mortality than their basal cell counterparts.[5,15–17] Compared with the negligible metastasis and mortality rates demonstrated by basal cell carcinomas, squamous cell carcinomas have a metastasis rate of 2%–6% and a mortality rate of 1.5%.[5,15–17] Once a tumor is diagnosed and its risk is classified, the provider may begin to develop a treatment plan that best suits the patient (Table 2).

SURGICAL EXCISION

In the absence of Mohs micrographic surgery, standard surgical excision with complete margin assessment is the gold-standard treatment for both low and high-risk non-melanoma skin cancers. When planning tumor resection, the surgeon must balance tissue conservation and tumor elimination. For low-risk malignancies, tumors should be resected along with their subcutaneous fat using 4-mm lateral margins.[6,7,18] In lower-risk areas of the face such as the cheek and forehead, 3-mm lateral margins may be used to improve cosmesis; however, the use of smaller margins increases the risk for incomplete excision and recurrence.[19] For high risk malignancies, it is recommended that surgeons utilize lateral margins > 10 mm and excise down to the first underlying anatomic plane.[6,7,18,20] During resection, the surgical specimen should be handled with care as to avoid damaging the tissue.[21] After removal, the specimen should be lightly irrigated with normal saline to remove excess blood and labeled for the purposes of orientation using markings or suture (Fig. 2).[21] Should fixation be indicated, the specimen is then placed in a tube containing a solution of 10% formalin. It is imperative that the volume of the solution is 10 times greater than that of the specimen to ensure that it is adequately fixed.[21] The specimen tube must always be labeled with a detailed description of the specimen, the location from which it was resected, and patient identifiers to minimize the risk of handoff-associated errors between the surgeon and pathologist. When performed properly, standard surgical excision and margin assessment results in 5-year cure rates, ranging from 90% to 99%.[22–27]

In anatomic locations where tissue conservation is of the greatest concern, such as the face, the surgeon may utilize frozen section or staged surgical excision techniques. Frozen section techniques are beneficial as they conserve tissue and allow for immediate reconstruction once the

Table 2. Comparing Treatment Modalities for Low-risk and High-risk Non-melanoma Skin Cancers

Treatment Modality	5-Year Recurrence Rate	Benefits	Limitations
Low-risk lesions			
Standard surgical excision	2–5% BCC/SCC	Provides lowest rates of recurrence	Invasive procedure; outcomes highly dependent on surgeon
Electrodessication and curettage	1–9% BCC/SCC	Less invasive when compared with surgical excision	Does not permit histologic margin assessment; secondary intention wound healing results in hypopigmented scar; produces post-procedural alopecia in hair-bearing areas
Brachytherapy radiation therapy	1–8% BCC/SCC	Produces high-dose radiation with minimal impact to surrounding structures	Not readily available in many regions
External beam radiation therapy	5–15% BCC/SCC	Useful for nonsurgical candidates older than 60 years	Increases risk for future malignancy; complicates future excisions and reconstruction
Superficial, low-risk lesions			
Cryotherapy	1–5% BCC/SCC	Quick, cost-effective, no local anesthesia required	Potential for posttreatment prolonged edema, neuropathic pain, scarring, hypopigmentation
Photodynamic therapy	5–50% BCC/SCC‡	Superior cosmetic outcomes compared to surgical excision	Painful treatments; potential for posttreatment chronic open wounds and hyperpigmentation
Topical 5-FU and Imiquimod	10–15% BCC/SCC	Superior cosmetic outcomes compared to surgical excision	Prolonged treatment time; end result heavily dependent on patient's adherence to treatment
High-risk lesions			
Standard surgical excision	4–10% BCC; 8% SCC	Provides lowest rates of recurrence when MMS is not available	Invasive procedure; outcomes highly dependent on surgeon
Brachytherapy radiation therapy	6–13% BCC/SCC	Produces high-dose radiation with minimal impact to surrounding structures	Not readily available in many regions
External beam radiation therapy	14%	Useful for nonsurgical candidates older than 60 years	Increases risk for future malignancy; complicates future excisions and reconstruction

BCC, basal cell carcinoma; 5-FU, 5-fluorouracil; MMS, Mohs micrographic surgery; SCC, squamous cell carcinoma.
‡Data for photodynamic therapy outcomes of BCC/SCC provides recurrence rates at 1–3 years, no data available for 5-year recurrence.

margins are clear.[28] Although staged surgical excision is a more precise technique with lower recurrence rates, it is more expensive and requires patients to undergo multiple operations over the course of several days.[29,30]

ELECTRODESSICATION AND CURETTAGE

Electrodessication and curettage (EDC) is an ablative procedure that serves as an alternative to surgical excision for the treatment of low-risk non-melanoma skin cancers. EDC involves the use of a curette to mechanically debride malignant tissue followed by electrocoagulation for the purposes of hemostasis.[8] The curette preferentially removes malignant tissue during the debridement process because of the poor intercellular adhesion exhibited by cancerous cells.[31] The process of curettage and electrocoagulation is repeated multiple times until the provider feels that they have sufficiently removed the malignancy. The resulting wound is then allowed to heal secondarily. While less invasive than surgical excision, EDC produces an unsightly hypopigmented scar and often results in

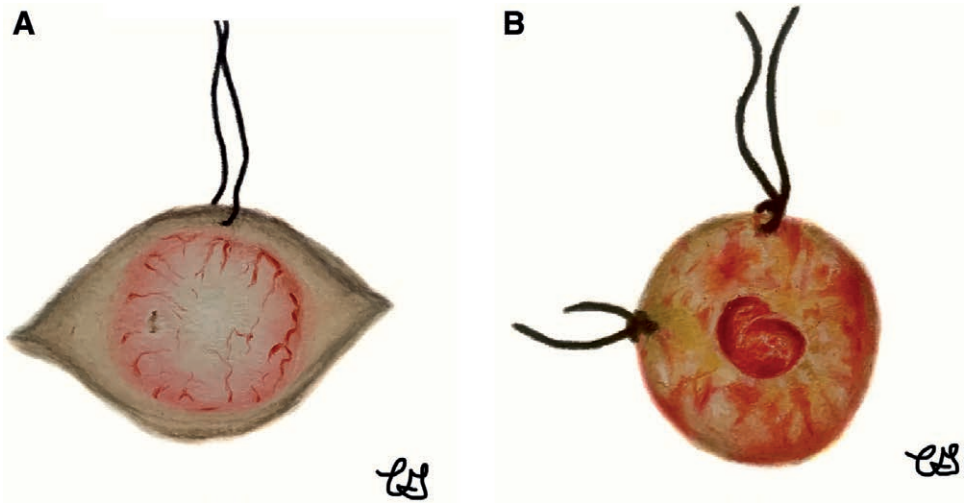

Fig. 2. Proper labeling of skin specimens. Skin specimens (including the outer layers of the skin) may be marked for orientation using a single suture at the 12 o'clock position (A). In contrast, deep specimens require a 3 o'clock or 9 o'clock suture so that the pathologist may identify the anterior aspect of the sample (B).

post-procedural alopecia.[8,31] Because of this, patients with non-melanoma skin cancers of the face and scalp may elect to undergo another form of treatment. Despite the 91%–99% 5-year cure rates seen in patients treated with EDC, histologic margin assessment is not possible in these patients, given the destructive nature of the procedure.[8,31–33] Because of this, patients and providers should pay close attention to the treatment area for signs of recurrence.

CRYOSURGERY

Cryosurgery is a non-invasive procedure frequently employed to treat superficial, low risk non-melanoma skin cancers. Cryosurgery uses a cryogen, usually in the form of liquid nitrogen, to eradicate malignant tissue by exposing the tumor to multiple cycles of freezing and thawing.[8,34] Compared with standard surgical excision and EDC, cryosurgery is associated with minimal post-procedural morbidity and typically has excellent aesthetic outcomes. Although rare, patients have reported neuropathic pain, hypertrophic scarring, and depigmentation after undergoing cryosurgery.[35] When treating superficial, low-risk non-melanoma skin cancers, cryosurgery has a 5-year recurrence rate, ranging from 1% to 5%.[36–38] While effective at treating superficial, low-risk malignancies, cryosurgery is more often used to treat actinic keratoses—a premalignant lesion associated with squamous cell carcinoma. Cryosurgery is highly effective for the treatment of actinic keratoses, with clearance rates reaching 99%.[39]

PHOTODYNAMIC AND TOPICAL THERAPIES

Photodynamic therapy and topical pharmacotherapy are other non-invasive interventions that may be utilized to treat superficial, low-risk non-melanoma skin cancers. Photodynamic therapy begins with topical application of a solution containing photosensitive porphyrins, such as aminolaevulinic acid and methyl-aminolaevulinic acid, to the affected tissue.[8,35] After a latency period of 4–20 hours, the photosensitive porphyrins are illuminated with visible light and produce radical oxidative species that are cytotoxic to the malignancy.[8,35] Most regimens include 2 or more treatments and can produce clearance rates ranging from 50% to 95%.[8,40–43] This treatment is generally well-tolerated, though patients may suffer from pain, chronic open wounds, and hyperpigmentation.[35]

Topical pharmacotherapy usually comes in the form of 5-fluorouracil and imiquimod creams. 5-fluorouracil and imiquimod disrupt the proliferation of neoplastic cells by inhibiting nucleic acid synthesis and activating the immune system to remove the malignancy, respectively.[8] These medications are applied by the patient multiple times a day over a period of 2–3 months.[35,44–46] The outcomes of topical pharmacotherapy are heavily dependent on patient compliance but exhibit cure rates ranging from 85%–90%.[8,44–46] Common side effects of pain, erythema, and severe pruritis, along with the high associated cost of both medications, may result in poor patient compliance or premature cessation of treatment.[35,44]

While surgical excision has superior clearance rates, PDT and topical pharmacotherapy have demonstrated superior cosmetic outcomes than surgical excision, making them attractive alternatives for malignancies of the head and neck.[8,46] Additionally, these interventions may be used to treat the skin adjacent to the malignancy to prevent the development of future malignancies.[47,48]

RADIATION THERAPY

Radiation therapy is a less commonly employed treatment modality for non-melanoma skin cancers. External beam radiation techniques are highly effective at treating non-melanoma skin cancers of the head and neck.[35,49] In external beam radiation therapy, high energy beams are generated by an external device and are transmitted into the malignancy with the goal of disrupting cellular replication.[35,49] While effective, external beam radiation therapy is primarily used to treat malignancies in patients over the age of 60 under special circumstances.[8,35] In short, this form of radiation therapy is most often indicated in patients who are poor surgical candidates or have perineural or large nerve involvement.[6,7] This is because external beam radiation therapy promotes tumorigenesis and can alter the structure of normal surrounding tissue, thereby complicating future excisions and reconstructions.[8,35] The reported 5-year recurrence rates of non-melanoma skin cancers treated with external beam radiation therapy range from 5% to 15%; however, squamous cell carcinomas tend to develop resistance with each treatment.[8,35]

Brachytherapy has become an increasingly popular alternative to external beam radiation for the treatment of non-melanoma skin cancers. Brachytherapy is a form of radiation therapy where high doses of radiation are directly applied to the malignancy.[35,49] The direct application of radiation maximizes the therapeutic effects of radiotherapy while minimizing the exposure of surrounding tissue to radiation.[35,49] Brachytherapy is particularly useful for treating well-circumscribed malignancies in facial regions where surgical excision may result in a less-favorable cosmetic outcome.[49] The reported 5-year recurrence rates of non-melanoma skin cancers following brachytherapy range from 1% to 13%.[49] It should be noted, however, that there are limited data describing the long-term effects of brachytherapy for the treatment of non-melanoma skin cancer. Lastly, forms of brachytherapy specifically designed for the treatment of non-melanoma skin cancers are not as readily available as external beam radiation and standard surgical excision in many geographic regions.

CHEMOTHERAPEUTIC AGENTS

Chemotherapeutic agents may be employed in cases of advanced local or metastatic disease.[6,7] Hedgehog pathway inhibitors, such as vismodegib and sonidegib, may be used to treat advanced basal cell carcinoma.[8,35] These medications selectively inhibit the smoothened protein receptor, which is frequently involved in the pathogenesis of this malignancy.[8,35] These medications are primarily used to shrink large tumors before surgical excision due

to the severe side-effect profile associated with extended treatment.[8,35] Advanced and metastatic squamous cell carcinomas may be treated with a wide variety of systemic chemotherapeutic agents, though these treatments are associated with inconsistent response rates and severe side effects.[35]

POSITIVE MARGINS AND RECURRENCE

The presence of positive margins upon histologic examination of the surgical specimen warrants further treatment. The management of patients with positive margins is largely dependent on the patient's ability to undergo surgical excision or radiation therapy.[6,7] In the absence of Mohs micrographic surgery, patients with positive margins are treated with further excision regardless of their tumor's pre-excision risk classification.[6,7] Frozen section techniques are recommended in these cases to ensure that the margins are sufficiently clear before reconstruction.[6,7] Patients who are unsuitable candidates for surgery should undergo radiation therapy.[6,7] A multidisciplinary tumor board should be consulted in cases where negative margins cannot be achieved and surgical excision and radiation therapy can no longer be tolerated.[6,7] The tumor board can then decide which form of chemotherapy would be able to best treat the patient's malignancy.

All recurrent tumors are treated as high-risk malignancies regardless of their pre-interventional risk classification.[6–8] Recurrent tumors that remain localized without signs of invasion are treated with surgical excision or radiation therapy. Tumors with nodal or systemic metastasis necessitate consultation of a multidisciplinary tumor board for further management.[7,8]

FOLLOW-UP

The importance of patient education and proper tumor surveillance following the treatment of a non-melanomas skin cancer cannot be understated. This is because patients with a history of non-melanoma skin cancer have a 10-fold risk of developing a second malignancy with 30%–50% developing a new lesion within 5 years.[6,7] Patients should be scheduled for follow-up appointments every 2–3 months for the first 2 years following treatment.[6–8] After 2 years, patients may follow-up with their provider every 6 to 12 months.[6–8] At each follow-up visit, the provider should conduct a full-body skin check, treat precancerous lesions, and biopsy lesions that are suspicious for malignancy. Patients must also be educated about the importance of sun protection and the cessation of tanning bed use, if applicable, as these behavioral modifications can lower the risk of developing novel malignancies.[6–8] Avoidance of midday sun exposure along with the use of protective clothing and sunscreen are all modifiable risk factors that prevent the development of future malignancies.[6–8]

RECONSTRUCTION

Oncologic reconstruction following surgical excision of non-melanoma skin cancer is highly dependent on the risk classification of the tumor and the size and location of the post-excisional defect.[8] Delaying oncologic reconstruction until negative margins are confirmed on histology lowers the risk of tumor seeding and the need for multiple reconstructive procedures. While patients with high-risk malignancies should always have confirmed negative margins before reconstruction, patients with low-risk malignancies may elect to undergo immediate reconstruction.[8] Reconstruction of post-excisional defects located on the face poses several challenges for the plastic surgeon. The surgeon must exhibit exceptional creativity when reconstructing a facial defect as minor irregularities of the face are highly distinguishable.[50] Furthermore, the concave and convex nature of many facial structures requires a thorough understanding of wound healing and how it may affect surrounding structures.[51] Herein, we will discuss several reconstructive modalities used for the treatment of facial defects following surgical resection of non-melanoma skin cancer.

Starting at the bottom of the reconstructive ladder, healing by secondary intention is a viable option for reconstructing excisional defects. Secondary wound closure may be used for small, superficial defects located in

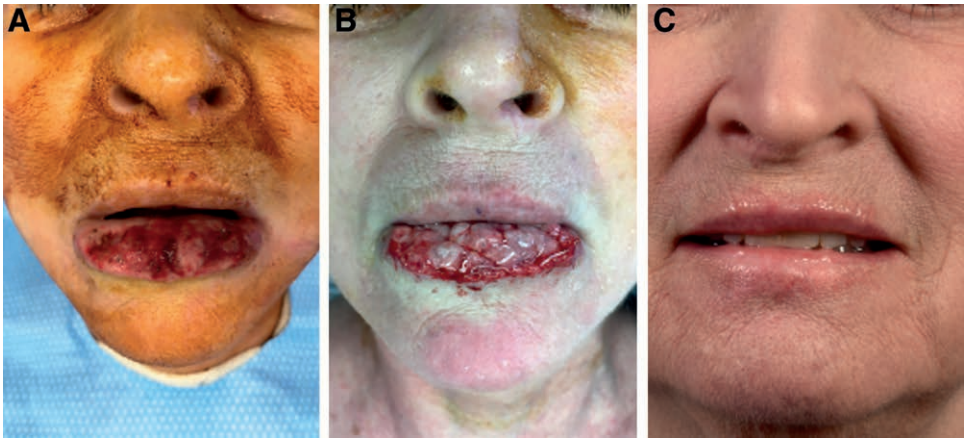

Fig. 3. Patient with a post-excisional defect involving the entire vermillion of the lower lip (A). Application of biologic acellular dermal matrix (B). Patient 3 months postoperatively (C).

areas where the risk of structural distortion secondary to wound contraction is low.[52] While this form of reconstruction is non-invasive, patients are often left with an unsightly hypopigmented scar that may be undesirable for some patients.[52] The advent of biologic wound agents has permitted secondary closure to be applied broadly with significant improvements in aesthetic outcomes.[8] For example, reconstruction of isolated vermillion defects using traditional methods, such as myomucosal tongue flaps, has largely been replaced by secondary closure with the use biologic wound agents because of their superior aesthetic outcomes and absence of donor site morbidity (Fig. 3).[50]

Linear closure with excision of dog ears is frequently used to treat a multitude of facial defects. This form of reconstruction is most effective in areas of greater laxity such as the cheek, lip, and forehead and is particularly useful in elderly patients.[50,53,54] Compared with more complex reconstructive techniques, linear closure often produces equivalent or even superior cosmetic outcomes when used

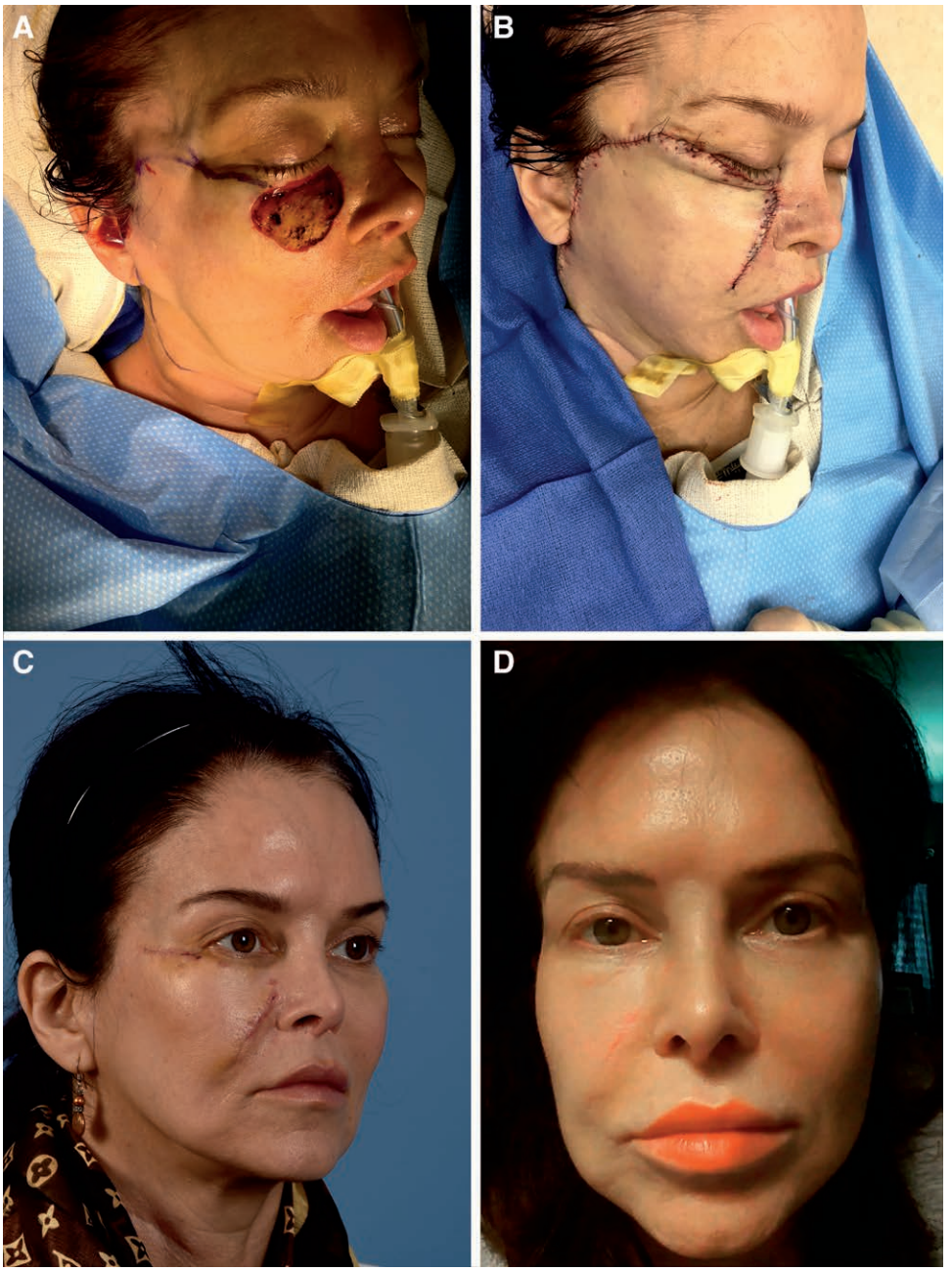

Fig. 4. Patient with a large, circumferential defect of the infraorbital cheek following excision of her malignancy (A). The defect was reconstructed utilizing a cervicofacial flap (B). Patient 3 weeks postoperatively without signs of ectropion or lip retraction (C). Patient 1 year postoperatively with minimal scarring (D).

to treat large defects.[54] Additionally, the complications associated with locoregional tissue transfer, such as flap loss, are non-existent in reconstruction by linear closure.[54]

Skin grafting is frequently utilized for facial reconstruction following surgical excision. Full-thickness skin grafts are used to treat small, superficial facial defects and can produce excellent aesthetic results if the graft is color-matched to the tissue surrounding the defect.[51,53,55,56] Split-thickness skin grafts are primarily used to cover large defects, particularly those of the scalp, because of the minimal donor site morbidity associated with harvest.[8] Skin grafts require an underlying vascular bed to survive after placement over the defect. Should an adequate vascular bed not exist, acellular dermal matrices may be used to develop one before graft placement.[8]

Locoregional tissue transfer is frequently employed to treat large, complex deformities of the face.[8,57,58] Reconstruction of defects involving the cutaneous portion of the upper lip, also known as the ergotrid, is challenging due to the risk of distorting the philtral columns and adjacent structures.[50,59] Small rotational flaps, such as the ergotrid flap, may be used to correct these defects while

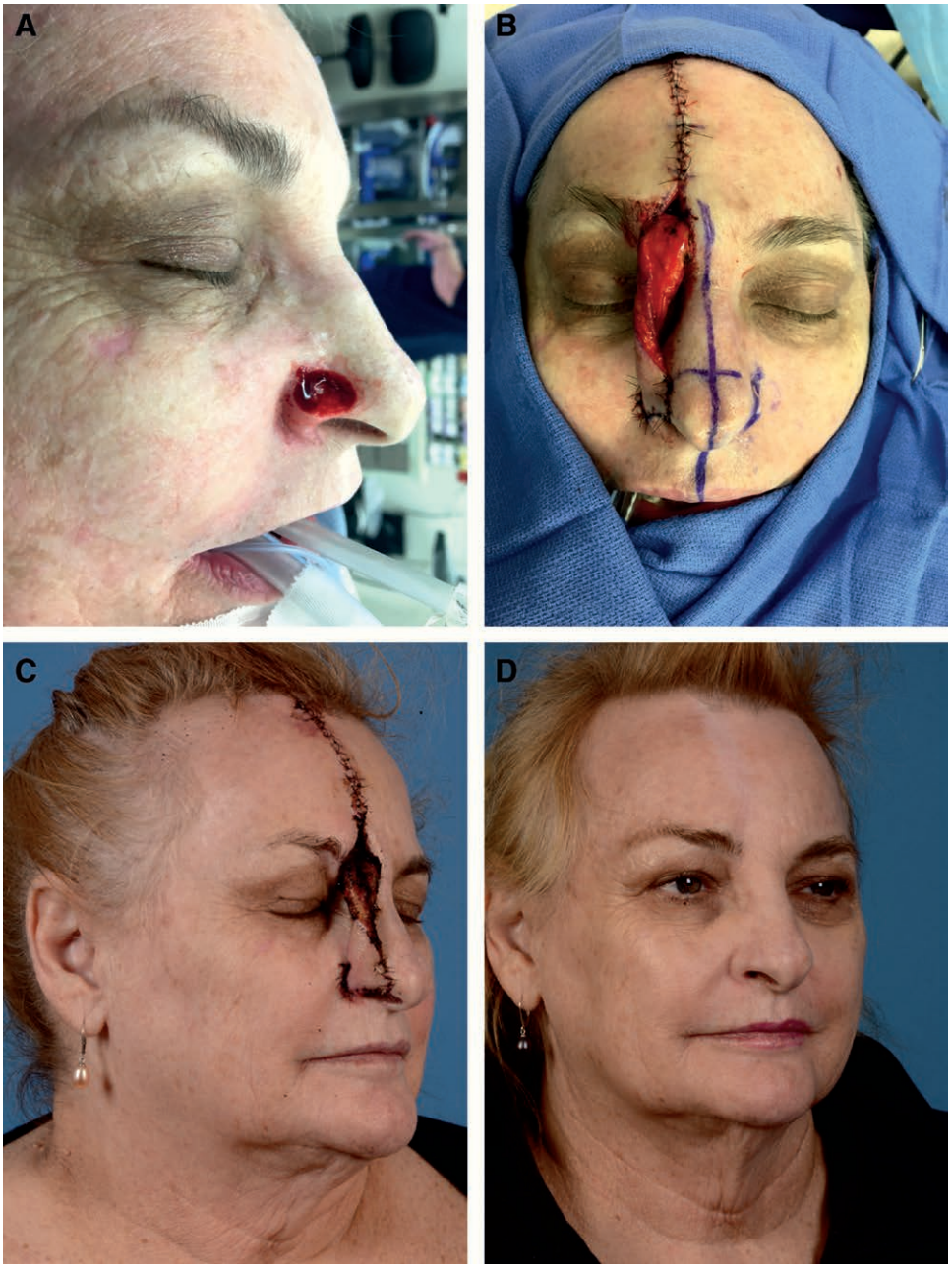

Fig. 5. Patient with a full-thickness defect of the nasal ala following excision of a nonmelanoma skin cancer (A). Inset of the paramedian forehead flap into the alar defect (B). Patient 3 weeks post-operatively following inset of the flap (C). Patient 3 months postoperatively following flap division and inset (D).

preserving the natural structure of surrounding anatomy should linear closure be contraindicated.[59] Similar to defects of the ergotrid, reconstruction of large defects of the cheek is complicated by its proximity to the lip, nose, and eye.[53] Large rotational flaps, such as the cervicofacial flap, allow the surgeon to mimic the color and texture of tissue surrounding the defect while minimizing the risk of distorting said structures (Fig. 4).[53]

Regional flaps, such as the paramedian forehead flap, are frequently employed to reconstruct the nose (Fig. 5).[56,60] This interpolated flap, along with cartilage grafting, is used to provide coverage, lining, and support to the reconstructed nose in a 2-stage procedure. This procedure is considered to be the gold standard treatment for complex nasal reconstruction because it produces excellent aesthetic outcomes with minimal donor site morbidity.[60] In addition to its efficacy, this procedure has demonstrated complication rates as low as 4%, making it a reliable and safe reconstructive modality.[60]

CONCLUSIONS

The annual rise in incident non-melanoma skin cancer necessitates that plastic surgeons become more familiar with the diagnosis, management, and prevention of these malignancies. In the absence of Mohs micrographic surgery, surgical excision is the gold-standard treatment for non-melanoma skin cancers. Despite this, there are a multitude of available treatment modalities that may be more desirable in certain circumstances. Reconstruction of the face is highly complex; however, techniques lower on the reconstructive ladder, such as linear closure, should not be overlooked because they can produce excellent aesthetic results with minimal morbidity. The prevention of malignancy is best done by educating patients about modifiable risk factors and treating precancerous lesions.

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REFERENCES

1. Rogers HW, Weinstock MA, Feldman SR, Coldiron BM. Incidence estimate of nonmelanoma skin cancer (keratinocyte carcinomas) in the US population, 2012. *JAMA Dermatol.* 2015;151:1081–1086.
2. Rogers HW, Weinstock MA, Harris AR, et al. Incidence estimate of nonmelanoma skin cancer in the United States, 2006. *Arch Dermatol.* 2010;146:283–287.
3. Muzic JG, Schmitt AR, Wright AC, et al. Incidence and trends of basal cell carcinoma and cutaneous squamous cell carcinoma: a population-based study in Olmsted County, Minnesota, 2000 to 2010. *Mayo Clin Proc.* 2017;92:890–898.
4. Miller DL, Weinstock MA. Nonmelanoma skin cancer in the United States: incidence. *J Am Acad Dermatol.* 1994;30(5 Pt 1):774–778.
5. Karia PS, Han J, Schmults CD. Cutaneous squamous cell carcinoma: Estimated incidence of disease, nodal metastasis, and deaths from disease in the United States, 2012. *J Am Acad Dermatol.* 2013;68:957–966.
6. National Comprehensive Cancer Network. National clinical practice guidelines in oncology: basal cell skin cancer. Available at https://www.nccn.org/professionals/physician_gls/pdf/nmsc.pdf. Accessed April 28, 2020.
7. National Comprehensive Cancer Network. National clinical practice guidelines in oncology: squamous cell skin cancer. Available at https://www.nccn.org/professionals/physician_gls/pdf/squamous.pdf. Accessed April 28, 2020.
8. Mendez BM, Thornton JF. Current basal and squamous cell skin cancer management. *Plast Reconstr Surg.* 2018;142:373e–387e.
9. Kadouch DJ, Leeflang MM, Elshot YS, et al. Diagnostic accuracy of confocal microscopy imaging vs. punch biopsy for diagnosing and subtyping basal cell carcinoma. *J Eur Acad Dermatol Venereol.* 2017;31:1641–1648.
10. Mosterd K, Thissen MR, van Marion AM, et al. Correlation between histologic findings on punch biopsy specimens and subsequent excision specimens in recurrent basal cell carcinoma. *J Am Acad Dermatol.* 2011;64:323–327.
11. Roozeboom MH, Mosterd K, Winnepenninckx VJ, et al. Agreement between histological subtype on punch biopsy and surgical excision in primary basal cell carcinoma. *J Eur Acad Dermatol Venereol.* 2013;27:894–898.
12. Haws AL, Rojano R, Tahan SR, et al. Accuracy of biopsy sampling for subtyping basal cell carcinoma. *J Am Acad Dermatol.* 2012;66:106–111.
13. Schell AE, Russell MA, Park SS. Suggested excisional margins for cutaneous malignant lesions based on Mohs micrographic surgery. *JAMA Facial Plast Surg.* 2013;15:337–343.
14. Choi JH, Kim YJ, Kim H, et al. Distribution of basal cell carcinoma and squamous cell carcinoma by facial esthetic unit. *Arch Plast Surg.* 2013;40:387–391.
15. Nguyen TH. Mechanisms of metastasis. *Clin Dermatol.* 2004;22:209–216.
16. Fu T, Aasi SZ, Hollmig ST. Management of high-risk squamous cell carcinoma of the skin. *Curr Treat Options Oncol.* 2016;17:34.
17. Brantsch KD, Meisner C, Schönfisch B, et al. Analysis of risk factors determining prognosis of cutaneous squamous-cell carcinoma: a prospective study. *Lancet Oncol.* 2008;9:713–720.
18. Kiely JR, Patel AJK. A retrospective study of 694 basal cell carcinoma excisions to quantify deep margin documentation and clearance compared to histological type and surgical margin. *J Plast Reconstr Aesthet Surg.* 2019;72:1805–1812.
19. Kimyai-Asadi A, Alam M, Goldberg LH, Peterson SR, Silapunt S, Jih MH. Efficacy of narrow-margin excision of well-demarcated primary facial basal cell carcinomas. *J Am Acad Dermatol.* 2005;53:464–468.
20. Wolf DJ, Zitelli JA. Surgical margins for basal cell carcinoma. *Arch Dermatol.* 1987;123:340–344.
21. Nischal U, Nischal KC, Khopkar U. Techniques of skin biopsy and practical considerations. *J Cutan Aesthet Surg.* 2008;1:107–111.
22. Walker P, Hill D. Surgical treatment of basal cell carcinomas using standard postoperative histological assessment. *Australas J Dermatol.* 2006;47:1–12.
23. Thissen MRTM, Neumann MHA, Schouten LJ. A systematic review of treatment modalities for primary basal cell carcinomas. *Arch Dermatol.* 1999;135:1177–1183. 10.1001/archderm.135.10.1177
24. Drucker AM, Adam GP, Rofeberg V, et al. Treatments of primary basal cell carcinoma of the skin: a systematic review and network meta-analysis. *Ann Intern Med.* 2018;169:456–466.
25. Lansbury L, Bath-Hextall F, Perkins W, et al. Interventions for non-metastatic squamous cell carcinoma of the skin: systematic review and pooled analysis of observational studies. *BMJ.* 2013;347:f6153.
26. Övermark M, Koskenmies S, Pitkänen S. A retrospective study of treatment of squamous cell carcinoma in situ. *Acta Derm Venereol.* 2016;96:64–67.

27. Rowe DE, Carroll RJ, Day CL. Long-term recurrence rates in previously untreated (primary) basal cell carcinoma: implications for patient follow-up. *J Dermatol Surg Oncol*. 1989;15:315–328.
28. Nicoletti G, Brenta F, Malovini A, et al. Study to determine whether intraoperative frozen section biopsy improves surgical treatment of non-melanoma skin cancer. *Mol Clin Oncol*. 2013;1:390–394.
29. Hüsler R, Schlittler FL, Kreutziger J, et al. Staged surgical therapy of basal cell carcinoma of the head and neck region: an evaluation of 500 procedures. *Swiss Med Wkly*. 2008;138:746–751.
30. Niederhagen B, von Lindern JJ, Bergé S, et al. Staged operations for basal cell carcinoma of the face. *Br J Oral Maxillofac Surg*. 2000;38:477–479.
31. Barlow JO, Zalla MJ, Kyle A, et al. Treatment of basal cell carcinoma with curettage alone. *J Am Acad Dermatol*. 2006;54:1039–1045.
32. Werlinger KD, Upton G, Moore AY. Recurrence rates of primary nonmelanoma skin cancers treated by surgical excision compared to electrodesiccation-curettage in a private dermatological practice. *Dermatol Surg*. 2002;28:1138–42; discussion 1142.
33. Motley R, Kersey P, Lawrence C. Multiprofessional guidelines for the management of the patient with primary cutaneous squamous cell carcinoma. *Br J Plast Surg*. 2002;146:18–25.
34. Kuflik EG. Cryosurgery for cutaneous malignancy: an update. *Dermatologic Surg*. 1997;23:1081–1087.
35. Collins A, Savas J, Doerfler L. Nonsurgical treatments for nonmelanoma skin cancer. *Dermatol Clin*. 2019;37:435–441.
36. Kuflik EG. Cryosurgery for skin cancer: 30-year experience and cure rates. *Dermatol Surg*. 2004;30(2 Pt 2):297–300.
37. Holt PJ. Cryotherapy for skin cancer: results over a 5-year period using liquid nitrogen spray cryosurgery. *Br J Dermatol*. 1988;119:231–240.
38. Mallon E, Dawber R. Cryosurgery in the treatment of basal cell carcinoma. *Dermatologic Surg*. 1996;22:854–858.
39. Lubritz RR, Smolewski SA. Cryosurgery cure rate of actinic keratoses. *J Am Acad Dermatol*. 1982;7:631–632.
40. Fantini F, Greco A, Del Giovane C, et al. Photodynamic therapy for basal cell carcinoma: clinical and pathological determinants of response. *J Eur Acad Dermatol Venereol*. 2011;25:896–901.
41. Kibbi N, Zhang Y, Leffell DJ, et al. Photodynamic therapy for cutaneous squamous cell carcinoma in situ: impact of anatomic location, tumor diameter, and incubation time on effectiveness. *J Am Acad Dermatol*. 2020;82:1124–1130.
42. Fink-Puches R, Soyer HP, Hofer A, et al. Long-term follow-up and histological changes of superficial nonmelanoma skin cancers treated with topical delta-aminolevulinic acid photodynamic therapy. *Arch Dermatol*. 1998;134:821–826.
43. Wang I, Bendsoe N, Klinteberg CA, et al. Photodynamic therapy vs. cryosurgery of basal cell carcinomas: results of a phase III clinical trial. *Br J Dermatol*. 2001;144:832–840.
44. Chitwood K, Etzkorn J, Cohen G. Topical and intralesional treatment of nonmelanoma skin cancer: efficacy and cost comparisons. *Dermatol Surg*. 2013;39:1306–1316.
45. Arits AH, Mosterd K, Essers BA, et al. Photodynamic therapy versus topical imiquimod versus topical fluorouracil for treatment of superficial basal-cell carcinoma: a single blind, non-inferiority, randomised controlled trial. *Lancet Oncol*. 2013;14:647–654.
46. Bath-Hextall F, Ozolins M, Armstrong SJ, et al; Surgery versus imiquimod for nodular superficial basal cell carcinoma (SINS) study group. Surgical excision versus imiquimod 5% cream for nodular and superficial basal-cell carcinoma (SINS): a multicentre, non-inferiority, randomised controlled trial. *Lancet Oncol*. 2014;15:96–105.
47. Weinstock MA, Thwin SS, Siegel JA, et al. Chemoprevention of basal and squamous cell carcinoma with a single course of fluorouracil, 5%, cream: a randomized clinical trial. *JAMA Dermatol*. 2018;154:167–174.
48. Neugebauer R, Su KA, Zhu Z, et al. Comparative effectiveness of treatment of actinic keratosis with topical fluorouracil and imiquimod in the prevention of keratinocyte carcinoma: a cohort study. *J Am Acad Dermatol*. 2019;80:998–1005.
49. Skowronek J. Brachytherapy in the treatment of skin cancer: an overview. *Postepy Dermatol Alergol*. 2015;32:362–367.
50. Sanniec K, Harirah M, Thornton JF. Lip reconstruction after Mohs cancer excision: lessons learned from 615 consecutive cases. *Plast Reconstr Surg*. 2020;142:533–542.
51. McCluskey PD, Constantine FC, Thornton JF. Lower third nasal reconstruction: when is skin grafting an appropriate option? *Plast Reconstr Surg*. 2009;124:826–835.
52. Odland PB, Murakami CS. Healing by secondary intention. *Oper Tech Otolaryngol - Head Neck Surg*. 1993;4:54–60.
53. Rapstine ED, Knaus WJ II, Thornton JF. Simplifying cheek reconstruction: a review of over 400 cases. *Plast Reconstr Surg*. 2012;129:1291–1299.
54. Soliman S, Hatef DA, Hollier LH Jr, et al. The rationale for direct linear closure of facial Mohs' defects. *Plast Reconstr Surg*. 2011;127:142–149.
55. Fulchiero GJ, Taylor RS, Thornton JF. Expandable desiccated ear wicks aid in skin graft reconstruction of the external auditory canal after Mohs micrographic surgery: how we do it. *Dermatologic Surg*. 2010;36:942–943.
56. Thornton JF, Griffin JR, Constantine FC. Nasal reconstruction: an overview and nuances. *Semin Plast Surg*. 2008;22:257–268.
57. Thornton JF, Reece EM. Submental pedicled perforator flap: V-Y advancement for chin reconstruction. *Plast Reconstr Surg*. 2008;122:468–470.
58. Thornton JF, Weathers WM. Nasolabial flap for nasal tip reconstruction. *Plast Reconstr Surg*. 2008;122:775–781.
59. Becker S, Lee MR, Thornton JF. Ergotrid flap: a local flap for cutaneous defects of the upper lateral lip. *Plast Reconstr Surg*. 2011;128:460e–464e.
60. Sanniec K, Malafa M, Thornton JF. Simplifying the forehead flap for nasal reconstruction: a review of 420 consecutive cases. *Plast Reconstr Surg*. 2017;140:371–380.