Introduction

More than 500,000 new cases of non-melanoma skin cancers are diagnosed and treated annually in the United States. More than 80% of these cancers occur on the head and neck. Most are effectively treated and cured by physicians using modalities including excision, electrodesiccation and curettage, cryosurgery, and radiation therapy. A subset of these skin cancers, however, result in significant functional and cosmetic morbidity and, on occasion, mortality. These difficult tumors are best treated with Mohs micrographic surgery, which provides the highest possible cure rates while it maximizes the preservation of normal tissue. Following excision, many of these cancers leave significant soft tissue and sometimes structural defects. Many techniques from skin grafting to complex facial flaps have been developed to deal with these defects. Each region of the head and neck presents its own challenging and unique anatomy to the reconstruction.

Skin Anatomy

Many surgeons cut through the skin every day without a true understanding of the complex organization and cellular structure of one of the largest organs in the human body. Skin is composed of epidermis and dermis. The dermis is of different thickness over different regions of the body. Most of the skin is hair bearing or nonglabrous, and other areas are smooth non-hairbearing or glabrous. The epidermis is composed of keratinizing stratified squamous epithelium. Four cell types are present: keratinocytes, melanocytes, Langerhans cells, and Merkel cells. Keratinocytes make up the bulk of the cells in the four epidermal layers; stratum basale, stratum spinosum, stratum granulosum, and stratum corneum, from deep to superficial. Melanocytes are of neural crest origin and present only in the basal layer in a ratio of 1:4 to 1:10 melanocyte to basal cell. Their function is to produce melanin which is then packaged into melanosomes and transported to and picked up by the keratinocytes in the stratum spinosum. The number of melanocytes does not differ between races; the increased pigment is a function of increased melanosome production.

In the skin condition vitiligo, melanocytes are absent; in albinism, melanocytes are present but lack tyrosinase which functions to convert tyrosine to melanin. Langerhan cells are found in the suprabasilar epidermis primarily in the stratum spinosum and function as mediators of the immunologic
response. Merkel cells are found in both the epidermis and dermis in close association with peripheral nerve endings. They are thought to be slowly adopting touch receptors, however their function is unclear. Merkel cell tumors are thought to arise from these cells. The epidermis attaches to the dermis in the basement membrane zone. Tonofilaments in the basal cells condense and attach to an electron dense area, attachment plaque, known as a hemidesmosome. These basal cells are firmly anchored to the underlying lamina densa through connecting anchoring filaments in the lamina lucida. The dermis contains the major components of the pilosebaceous unit which then passes through the epidermis to emerge at the skin surface. The pilosebaceous unit includes the hair follicle, apocrine sweat gland, sebaceous gland and arrector pili muscle. It is the cells at the base of the hair follicle which are responsible for epidermal island buds in split thickness skin graft donor beds. The primary cell in the dermal layer is the fibroblast.

The dermis is broken into the superficial, papillary dermis and the deep, reticular dermis. It is primarily composed of a fibrous connective tissue of collagen, elastin, and ground substance, which is composed of fibronectin and the glycosaminoglycans, hyaluronic acid, chondroitin-4-sulfate, and dermatan sulphate. The collagen in the dermis decreases about 1%/year in adulthood. Ultraviolet light may stimulate keratinocytes to produce IL-1, which stimulates collagenase. Topical tretinoin increases the density of anchoring fibrils, possibly inhibiting collagenase. The skin itself contains two vascular plexuses, the superficial which is a rich capillary loop system in the superficial dermal papillae, and the deep which is at the junction of the dermis and subcutaneous fat. These two systems are connected by communicating vessels in the reticular dermis.

Mohs Surgery

In the 1930’s, while a medical student, Frederick E. Mohs developed an in vivo chemical fixation technique using a zinc chloride fixative paste which he combined with serial excision of the tumorous tissue and complete microscopic control of the resection margins. In 1941 he published his series of 440 cases of cancer in which he used his “chemosurgery technique.” Despite achieving a 99% 5-year cure rate for primary basal cell cancer, and a 96% cure rate for recurrent BCCA, the technique did not gain wide acceptance. The procedure took several days to complete with many resections, the postoperative slough continued for several weeks, and therefore the reconstruction was delayed or abandoned. In 1953, while treating eyelid cancer he developed a modification of his technique, “fresh tissue technique.”

It was not until 1970, Theodore Tromovitch presented 75 cases at the American College of Chemosurgery, using Mohs technique that the advantages of the procedure became clear. “Using the fresh-tissue technique, tissue sparing in tumor extirpation is maximized while maintaining high cure rates, and appropriate functional and cosmetic reconstruction can be performed immediately.” 1986 American College of Chemosurgery proposed nomenclature; Mohs micrographic surgery, fresh-tissue technique, and Mohs micrographic surgery, fixed-tissue technique. To perform Mohs surgery, first a diagnosis and histologic type are established using skin biopsy and conventional permanent histology. The majority of lesions are excised under local anesthesia using the following technique. The clinically apparent tumor is outlined, it is then de-bulked using a dermal curet, a saucer shaped layer of tissue is taken around and under the clinically apparent tumor with narrow margins. This is done taking great care to incise all the margins at a 45-degree angle. The specimen is oriented to the patient, labeled, and a map is drawn of both the specimen and the patient. The specimen is then divided into
appropriate sized pieces for processing. The tissue is compressed before freezing. The 45-degree cut when compressed, places the peripheral epidermal and dermal tissue in the same horizontal plane as the medial deep tissues. The entire specimen is then frozen and sectioned horizontally. 100% of the peripheral and deep margins are visualized. Any residual tumor is mapped to the patient and a 2nd excision is performed using the same process. This is continued until all margins are free of any tumor cells. The indications for Mohs excision BCCA and SCCA are as follows:

Table 1. Indications for Mohs Micrographic Surgery

<table>
<thead>
<tr>
<th>Indication</th>
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<tbody>
<tr>
<td>Recurrent skin cancer</td>
<td></td>
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<tr>
<td>Skin cancer in a &quot;high risk anatomic area&quot;</td>
<td></td>
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<tr>
<td>Histologically aggressive skin cancer</td>
<td></td>
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<tr>
<td>Large skin cancer</td>
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<tr>
<td>Skin cancer with ill-defined clinical margins</td>
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<tr>
<td>Incompletely excised skin cancer</td>
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<tr>
<td>Skin cancer in irradiated skin</td>
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<tr>
<td>Skin cancer in a cosmetically important area</td>
<td></td>
</tr>
<tr>
<td>Dermatofibrosarcoma protuberans</td>
<td></td>
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<tr>
<td>Selected mucosal squamous cell carcinomas</td>
<td></td>
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</tbody>
</table>

* Skin cancer refers to basal cell and squamous cell carcinoma only.
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Recurrent BCCA and SCCA tend to extend through the scar tissue in unpredictable ways. Mohs surgery provides the only way to examine all the margins and its effectiveness is demonstrated by the following table.

Table 2. Recurrence Rates for the Treatment of Recurrent Basal Cell Carcinoma

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Recurrence Rate</th>
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<tbody>
<tr>
<td>Electrodesication and curettage</td>
<td>40%—59%</td>
</tr>
<tr>
<td>Cryosurgery (short-term data only)</td>
<td>8%—19%</td>
</tr>
<tr>
<td>Radiation therapy</td>
<td>9%—51%</td>
</tr>
<tr>
<td>Surgical excision</td>
<td>5%—40%</td>
</tr>
<tr>
<td>Mohs micrographic surgery</td>
<td>3%—8%</td>
</tr>
</tbody>
</table>

Except for cryosurgery, the data refers to studies with at least 5-year follow-up.
From Oto Clinics of North America Oct. 1990 p 851

Basal cell carcinomas tend to spread along the path of least resistance; dermis, fascial planes, embryonic fusion planes, perichondrium, periosteum, neurovascular bundles. Certain areas in the head and neck are at increased risk for having extensive silent tumor invasion for these reasons. These areas form an “H” across the face on frontal view and include the nasal ala, nasal septum, nasal ala groove, periorbital region, periauricular region, region around and in the ear canal, ear pinna, and scalp. The most common types of BCCA are noduloulcerative and superficial types. These are treatable easily with conventional methods when Mohs is not otherwise indicated, however, histologically aggressive types such as morpheaform, sclerosing, infiltrating, or keratinizing, are much more invasive and the clinically apparent disease often underestimates the true microscopic spread.

For example, in a series of 51 morpheaform BCCA, the average subclinical spread from clinically apparent tumor was 7.2 mm. Mohs offers advantages over other techniques of resection for large skin cancers in that it provides maximum tissue preservation with reasonable assurance of tumor-free margins. For large cancers conventional techniques have a higher chance of missing a positive margin because of vertical sectioning and the large surface area of the margin excised. Incompletely excised BCCA recurs 33% of the time with positive margins at 2 years and 12% of the
time with margins within one high power field. The subcutaneous spread of the tissue can be very
difficult to estimate with conventional techniques. Carcinomas in irradiated skin also tend to be more
aggressive and have indistinct margins. Finally, in cosmetically important areas Mohs surgery offers
maximal tissue sparing with confidence in excision. Mohs is being considered for use for
dermatofibrosarcoma protuberans due to its high recurrence rates and indistinct tumor spread and
considered as an aid for mucosal SCCA. Most Mohs surgeons do not feel Mohs is an advantage for
Melanoma.

Reconstruction after Mohs

The reconstruction following Mohs excision can be as simple as grannulation to as complex as
free tissue transfer, but usually somewhere in between. The decision on how to reconstruct must be
shared by the patient and their wishes as well as the patient’s general medical condition and the
opinions of the surgeon as to the best procedure. The following paradigm is a good guide to
reconstruction after Mohs.

![Reconstruction flowchart](image)

If the patient has an absolute contraindication to surgery then the most appropriate option is
healing by secondary intention. This is rarely the case, however some defects heal with cosmetically
good results when left to mother nature. Healing by secondary intention is indicated for lesion of the
medial canthus less than 1 cm in dimension. It is also acceptable in the temple forehead, and
periauricular area. Some feel that certain lesions of the auricle heal well by this method as well. It is
relatively contraindicated for defects of the nasal ala, eyelid, and lip. The best option for closing a
defect is primarily if the wound is long and narrow or can be made so with the long axis in the relaxed
skin tension lines. Younger patients require more undermining than older patients with more relaxed
skin, but as a general guide one width of the wound on both sides near the center and a total of one width at the ends will provide a tension free closure. In order for this to be affective you must avoid distorting cosmetically nondistortable structures.

Another option to simple ellipse is to use M-plasty; the advantage of which is less tissue excision and shorter linear scar. The next option for reconstruction is a simple skin graft. Usually a full thickness graft is used on the face to avoid contraction. Survival of the graft depends upon adequate nutrition and removal of waste. In order for this to occur close contact with the bed is required without separation and the graft must be immobile. Adherence by fibrin exudate provides the medium for nutrition and waste removal until the outgrowth of capillary buds occurs on the 3rd or 4th day. The fibrin in infiltrated by fibroblasts which form a fibrous attachment by the 4th or 5th day. This process occurs well from a bed of muscle, periosteum, or perichondrium, but not from bare bone, cartilage, or tendon. Common donor sites for the head and neck include; preauricular, postauricular, melolabial fold, supraclavicular area, and for eyelid defects of the upper eyelid, contralateral eyelid skin. If the cosmetic results would be improved and if the patient is medically fit and agrees to the increased risk, than facial flaps are indicated for reconstruction. Defects and tissue for reconstruction must be analyzed based on the aesthetic units of the face. As with primary closure, design of a flap must not distort nondistortable structures. As much of the flap incision as possible should be placed in the relaxed skin tension lines, and the vector of force should be away from important structures. (See last page for flap design summary). As stated reconstruction after Mohs requires an assessment of each of the facial aesthetic units. Complete explanation of reconstruction of these units is the topic of entire books, and so obviously cannot be covered here. However, each areas high points of reconstruction and some simple options will be discussed.

Eyelid Reconstruction

When considering reconstruction of the eyelids function of the lids must be foremost consideration. The reconstruction must provide smooth mucous membrane internal lining, skeletal support equivalent to the tarsus, stable margin which keeps the lashes away from the cornea, proper fixation of medial and lateral canthal attachments, adequate muscle for closure, supple, thin skin to allow eyelid excursion, and adequate levator action to lift upper lid above visual axis. Deep component loss of greater than 1/3 to ½ of the lid requires complex approaches to repair. If the deep structure is present the eyelid can be closed by primary closure, FTSG, or rotation flaps. Upper eyelid
defects too large for primary closure are well closed with FTSG from the contralateral eyelid; preauricular or postauricular skin is the next best option. The lower eyelids are much more sensitive to contraction and ectropion, therefore skin grafting is only recommended for small defects less than one centimeter. Larger defects should be repaired with advancement, rotation flaps from cheek or other techniques. For primary closure of full thickness eyelid defects of 1/3 to ½ of the eyelid, the borders perpendicular to the eyelid margin are made into a pentagon by excision of tissue inferior to the tarsus. Use skin hooks to pull the edges together. If no tension than proceed with repair, however, if undo tension than a lateral cathothomy with cantholysis is performed.

Nasal Reconstruction

In evaluating a nasal defect the subunits of the nose and the tissue layers absent must be assessed. If greater than 50% of a subunit is missing, it is more aesthetically pleasing to resect the remainder of the subunit with the possible exception of the tip subunit, which may be divided vertically in the midline by some authors. Must replace all layers that are missing including nasal lining, cartilage, and soft tissue. The nasal subunits can be further grouped into convex subunits, dorsum, tip, alae, and columella, which are best reconstructed with flaps, and the concave subunits, soft triangle and nasal side walls, which do well with skin grafts. The thin skinned regions, dorsum, sidewalls, collumella, and lower half of the infratip lobule can be repaired by transposition flaps for defects less than 1.5 cm, or with preauricular skin grafts. The thick skinned regions of the alae, and upper nasal tip repair with a bilobed flap for lesion less than 1.5 cm. Larger lesions require paramedian forehead flap or nasolabial flap for the alar subunit.

The workhorse of nasal tip reconstruction is the paramedian forehead flap. It is an axial flap based on the supratrochlear artery primarily, but also nasal and supraorbital arteries. The course of the supratrochlear artery is deep to the obicularis oculi muscle traversing over the corrugator then piercing the temporalis at about the level of the brow to run in a superficial subcutaneous plane external to the frontalis muscle. This flap may be thinned at the distall 1-2 cm to near dermis because of the subcutaneous course of this artery. The pedicle may be as narrow as 1.2 cm to increase the arc of rotation. Another commonly used flap for nasal alae reconstruction is the superiorly based nasolabial, a.k.a. melolabial flap. Technically, this is an axial flap from perforators of levator labii superioris. To make the flap an incision is made in the melolabial fold then a lateral incision in made extending superiorly to the inferior extent of the defect so as to not narrow the pedicle. The flap is rotated and sewn into place dividing the pedicle in 2-3 weeks.

Cheek Reconstruction

Reconstruction in the cheek region is aided by laxity of the skin and relative abundance. Small to moderate defects can be closed primarily, otherwise a host of advancement, transposition, and rotation flaps can be used. Must not distort nondistortable structures and be wary of level of the facial nerve.

Forehead Reconstruction

The primary goal in forehead reconstruction is to maintain motor function and if possible sensory function while performing an aesthetically pleasing repair. The temporal branch of the facial nerve runs deep the temporalis muscle in the forehead area, but be wary to its superficial course laterally and especially over the zygomatic arch. Reconstructive hints include maintenance of brow
symmetry, maintenance of natural appearing temporal and frontal hairlines, hiding of scars when possible into hairlines and eyebrows, creation of transverse instead of vertical scars whenever possible (except in the midline), and avoidance of diagonal scars.

**Auricular Reconstruction**

Similar to nasal reconstruction in that both are cartilagenous in construction, in auricular reconstruction the regions of missing cartilage and layers of missing tissue must be assessed. Unlike the nose however, many auricular lesions may be allowed to heal by secondary intention. Barry reported on the results of 133 auricular defects left to heal by secondary intention that many healed with good to excellent results. The areas that did not heal well being the lobule almost always and the helical rim about 50% of the time. If the lesion is not appropriate for secondary intention or personal preference intervenes, skin grafting from posterior auricular skin for cutaneous lesions is a good option. Full thickness helical defects less than 1.5 cm in size can be closed primarily with wedge excision with little untoward effects. Lesions greater than 2 cm in size can be closed with composite graft from opposite ear ½ the size of the defect to finish with symmetrical auricles.

**Lip Reconstruction**

The lip is composed of three layers, skin, muscle and mucosa. The vermilion is modified mucosa defined at its anterior limit by the vermilion line and its posterior border by the innermost contact point with a closed mouth. Upper lip boundaries are the base of the nose, melolabial sulcus, and oral commisure. The lower lip boundaries are the oral commisure and the mental crease. The following algorithm provides a good guide to reconstruction. Please refer to more detailed texts for details.
Summary

Mohs surgery provides a useful technique for excision of BCCA and SCCA as well as other possible lesions in the future. Once the primary goal of removal of the cancer has been accomplished the reconstruction decisions are based upon patient desires and health as much as the physician opinion. Reconstruction should be based on the aesthetic subunits of the face and can range from the very simple to the very complex.
Bibliography


