

TITLE: Surgery and Reconstruction after Mohs Surgery

SOURCE: Grand Rounds Presentation, UTMB, Dept. of Otolaryngology

DATE: October 01, 2003

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Introduction

More than 500,000 new cases on 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

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 nonlabrous, 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. Langerhan cells are found in the suprabasilar epidermis primarily in the statum spinosum and function as mediators of the immunologic response.

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. 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 curette, 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:

- Recurrent skin cancer – 5 year control of >90% with Mohs.
- Skin cancer in a "high risk anatomic area" – ears, periauricular region, temporal region, periocular region, nasal tip ala, melolabial sulcus, upper lip.

- Histologically aggressive skin cancer – morpheaform, infiltrative type, sclerosing and basosquamous
- Large skin cancer – defined by the location of tumor excision
- Skin cancer with ill-defined clinical margins
- Skin cancer in irradiated skin
- Skin cancer in a cosmetically important area
- Dermatofibrosarcoma protuberans
- Selected mucosal squamous cell carcinomas

From Oto Clinics of North America Oct. 1990 p 850 and Clinical Otolaryngology Vol26(4) 265-273

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.

1. Electrodesiccation and curettage	40-59%
2. Cryosurgery (short-term data only)	8-19%
3. Radiation therapy	9-51%
4. Surgical excision	5-40%
5. Mohs micrographic surgery	3-8%

From Oto Clinics of North America Oct. 1990 p 851

Certain areas in the head and neck are at increased risk for having extensive silent tumor invasion for unclear 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. These areas often correlate with embryonic fusion planes, and they are often prone to more aggressive histologic subtypes of cancer. 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 7.2mm. 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 granulation 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.

Healing by secondary intention:

If the patient has an absolute contraindication to surgery then the most appropriate option is healing by secondary intention. Also, some defects heal well secondarily. 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. Concave areas of the face such as the nasolabial fold, nasolabial sulcus, and alar-facial groove often heal with excellent cosmetic results. Auricular lesions that tend to heal well by second intention include helical lesions with intact cartilage and perichondrium, antihelical lesions even with some cartilage loss, conchal lesions, pretragal and tragal areas, and posterior aspect of the auricle. It is relatively contraindicated for defects of the nasal ala, eyelid, and lip. However, a study by Deutsch *et al.* indicates that lower eyelid defects (especially partial thickness) can have very good cosmetic results by patient and doctor rating.

Primary Closure:

The best scenario for closing a defect primarily is 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. Maximum cosmesis requires avoidance of cosmetically nondistortable structures including the nasal tip, nasal alae, central upper lip, vermilion, oral and ocular commissures, eyelids and canthi, eyebrows, hairline, and earlobe. Good lender areas include the cheek, forehead, chin, submentum, and neck. Another option to simple ellipse is to use M-plasty; the advantage of which is less tissue excision and shorter linear scar.

Skin Grafting:

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 is 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.

Skin Flaps:

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.

There are two basic categories of locoregional skin flaps: axial and random. Random flaps represent the majority of local facial flaps. The vascular supply to random flaps arises from the subdermal plexus, ultimately supplied by musculocutaneous arteries. Thus, the appropriate plane of dissection is subcutaneous fat. Axial flaps derive their blood supply from the named direct cutaneous arteries. As a result, axial flaps are capable of a greater length:width ratio than random flaps. The plane of dissection is deeper, and must include the fascia containing the relevant named artery. Some additional length may be obtainable with axial flaps by including more tissue at the distal tip with blood supply of a random nature based upon the subdermal plexus. Examples of axial flaps include the paramedian forehead flap, based on the supratrochlear artery, and the nasolabial flap, based on the angular artery.

These two groupings are further broken down into 4 categories: rotation, transposition, advancement, and interpolated flaps. In rotation flaps, the defect sits immediately adjacent to the flap. The flap is rotated in an arc about a pivot point. The flap becomes functionally shorter as it is rotated, thus the flap must be designed such that it is longer than the defect. Back cuts can be performed at the base of the flap, but must be performed judiciously to protect the vascular supply. A standing cutaneous deformity will nearly always form at the base of a flap requiring a Burow's triangle. The axis of movement is curvilinear. The defect for a rotational flap must be triangular (or made to be triangular), and should have a 2:1 height: width ratio. The advantages of a rotational flap are that it involves only 2 sides, making it easier to place all edges in relaxed skin tension lines (RSTL) or the junction between aesthetic units.

Transposition flaps represent a type of rotation flap, though the final axis is linear. Transposition flaps also rotate about a pivot point, but there is an area of partially intact skin (NOT a complete bridge of skin) intervening between the donor site and the recipient site. Transposition flaps are particularly useful when one wants to transfer tension away from closure of the primary defect and into the repair of the secondary defect. A trapdoor (pin cushion) defect is common with transposition flaps. This refers to a dome-like elevation of the flap as compared to surrounding tissue. A trapdoor defect is best avoided by the performance of wide undermining around the defect and the use of vertical mattress sutures in wound closure. Examples of transposition flaps include the rhomboid and bilobed flaps.

Rhomboid Flap

A rhomboid (Limberg) flap is used for defects made into a rhombus (or 2 equilateral triangles placed base to base). The first limb of the flap should be continuous with the short diagonal of the rhomboid. Of note, the length of the short diagonal will equal the length of each side of the rhombus, which should equal the length of both limbs of the rhomboid flap.

An important variation of the rhomboid flap is the triple rhomboid, useful for larger defects. Of note, any triple rhomboid may be designed in 2 different ways.

Dufourmental Flap

This is another variation of the rhomboid flap in which all 4 sides of the defect are equal, but the angles differ from a Limberg flap. This defect is formed by 2 isosceles triangles placed base to base. The first limb of the flap is obtained by extending the short diagonal and the adjacent side and then bisecting the angle between these two lines. The second limb of the flap then parallels the long diagonal of the defect.

Bilobed Flap

This flap is particularly useful for circular defects involving the lower 1/3 of the nose measuring 1.5 cm or less in diameter. An angle of 45 degrees between lobes should be the goal with a final arc of transposition of 90-110 degrees. The first lobe should be ½ the width of the defect, and the second lobe ½ the width of the first lobe. A standing deformity is to be expected at the base of the flap, and a Burow's triangle is sometimes necessary. Wide undermining is important to avoid a trap door deformity. Another disadvantage of the bilobed flap is that the scar rarely follows RSTL.

Dorsal Nasal Flap

The important feature of this flap is that it must be much larger than the defect. It is useful for nasal defects less than or equal to 2.5 cm in diameter involving the middle or lower thirds of the nose. It is okay to use large back cuts because of good vascular supply to the nose. This flap can result in nasal tip elevation for midline defects, and asymmetric alar elevation for defects off midline. Thus, it is best applied to medial defects, and it is NOT good in patients with thick, sebaceous skin.

In advancement flaps, the movement of the flap is linear after wide undermining of the wound margins. It is often necessary to excise Burow's triangles near the base of the flap. The Burow's triangles often facilitate movement of the flap, but these should NOT be cut out until the advancing edge has been secured. The target length:width ratio of the flap should be approximately 1:2, and the distance the flap is advanced should approximate the width of the flap. Advancement flaps are useful for defects of the forehead and brow where RSTL are horizontal. Examples of advancement flaps are the monopodicle and bipedicle advancement flaps, the A-T flap, and the cheek advancement flap. The typical ratio of defect length to flap length for the monopodicle flap is 3:1. The bipedicle flap is usually employed when the monopodicle flap is not adequate.

Island Pedicle Flap

One type of advancement flap frequently referred to is the island pedicle (island advancement) flap, which is essentially a V-to-Y advancement flap. An island of skin is disconnected from its peripheral epidermal/dermal attachments such that it is only connected to the face by underlying subcutaneous tissue. The flap is then advanced into a defect that should be approximately the same size, and the donor site is closed in a V-to-Y fashion. One should NEVER undermine underneath an island advancement flap, though it is helpful to undermine *around* the flap. Island advancement flaps are especially good for defects of the lateral upper lip near the base of the nasal ala.

Interpolated flaps refer to axial pattern flaps where the donor site is separated from the defect by a complete bridge of intact skin. The flap may either pass over or under this skin. The flap may be divided after adequate blood supply is established. The paramedian forehead flap is an example.

Paramedian Forehead Flap

This flap is based on the supratrochlear artery, which is consistently located at a point 1 cm above the brow in a subdermal/subcutaneous plane approximately 2 cm from the midline. The pedicle for this flap may be narrowed to as little as 1.2 cm. A second procedure is required for division of the pedicle 3 weeks or more following the initial surgery. This is the flap of choice for large nasal defects. Disadvantages of this flap include the forehead donor site scar, limited length in patients with low hairlines, and the need for revision in many cases.

Melolabial (Nasolabial) Flap

Though not an interpolated flap, this flap, like the paramedian forehead flap, is an axial pattern flap. The nasolabial flap is based on the angular artery. This flap may be either superiorly or inferiorly based. The melolabial flap should not be used for superior nasal defects because doing so may result in lower eyelid ectropion. The major disadvantages of the melolabial flap is blunting of the nasofacial sulcus and asymmetry of the melolabial sulcus. The superiorly based flap is useful for defects of the central and lateral nasal dorsum as well as the nasal tip and ala. The inferiorly based flap is useful for upper and lower lip defects, the floor of the nose, and the columella, but particularly lateral upper lip defects NOT involving the vermillion border.

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 $1/2$ 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 $1/2$ 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 cathotomy 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, columella, 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 distal 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 is 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 cartilaginous 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 $\frac{1}{2}$ the size of the defect to finish with symmetrical auricles.

Lip Reconstruction

The lip is composed of three layers, skin, muscle and mucosa. The vermillion is modified mucosa defined at its anterior limit by the vermillion 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 commissure. The lower lip boundaries are the oral commissure and the mental crease. The following algorithm provides a good guide to reconstruction. Please refer to more detailed texts for details.

Figure 18-50 Algorithm for reconstruction of lower lip defects.

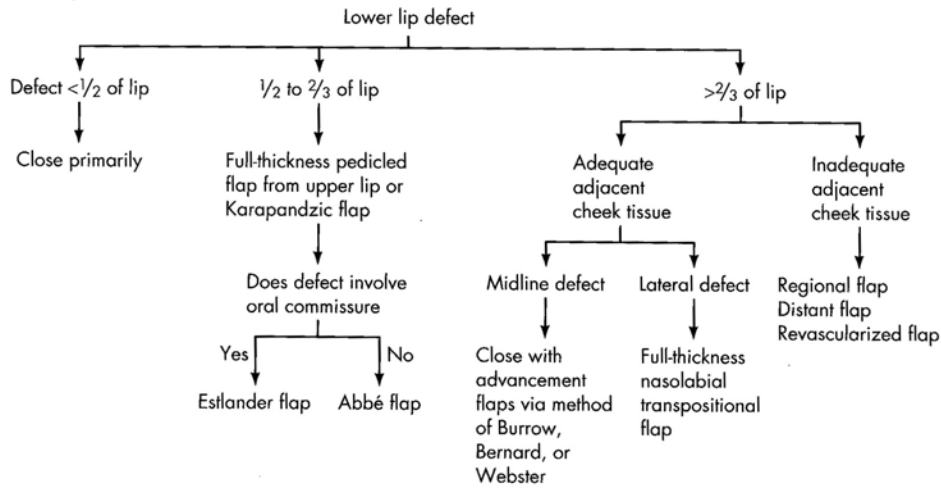
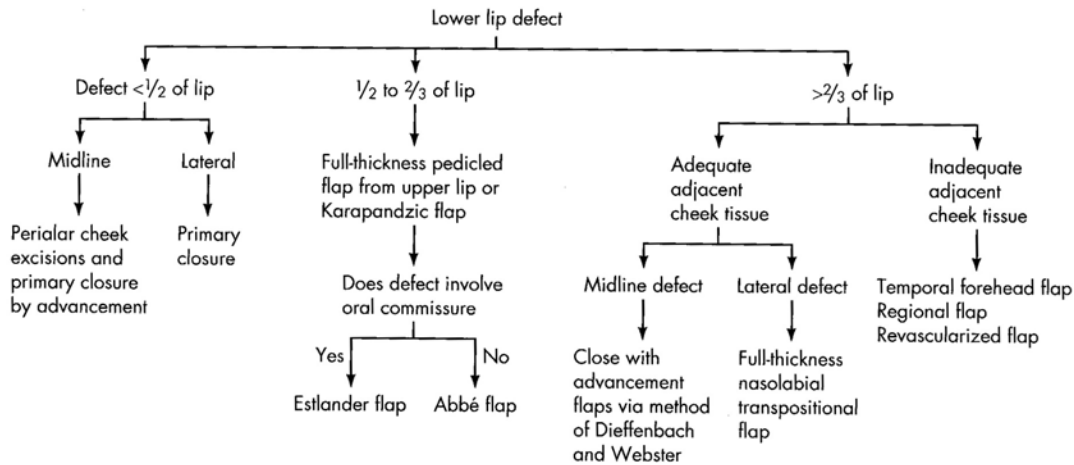


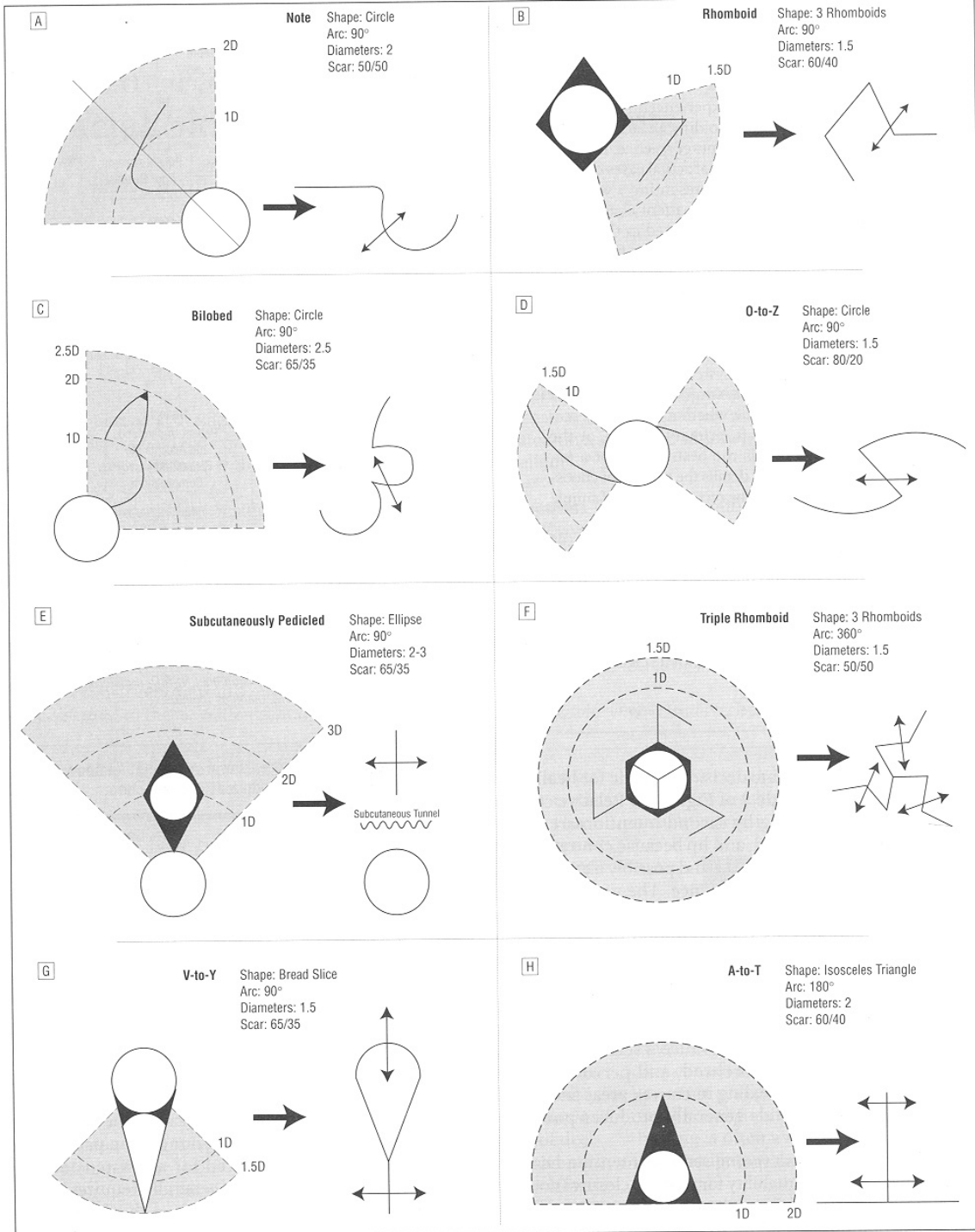
Figure 18-51 Algorithm for reconstruction of upper lip defects.



From Baker and Swanson, Local Flaps in Facial Reconstruction, Mosby 1995

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.



From Arch Oto, Vol 124 Calhoun, Seikaly, Quinn

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Paper adapted in part from Quinn Grand Rounds Archive: Edward Buckingham “Mohs Surgery and Reconstruction,” and Rick Rosen “Facial Flaps.”

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