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The role of Mohs’ micrographic surgery in the management of skin cancer and a perspective on the management of the surgical defect

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Mohs’ micrographic surgery (MMS) is best suited and offers the highest cure rates for tumors that grow in a contiguous manner and have a low potential for metastasis [1,2]. However, it is inappropriate to employ this technique for tumors that are capable of developing satellite lesions, as well as regional and systemic metastases (eg, melanoma, Merkel cell carcinoma). The major limitation of cancer surgery—whether it be MMS or routine surgical excision—is that if occult metastases are already present at the time of removal of the primary lesion, the patient will subsequently develop a recurrence, and is much less likely to survive his or her malignancy. In such cases, in retrospect, one may conclude that MMS offered no advantage over routine surgical removal; however, had occult metastases not been present, it is likely that the patient would have had an equivalent, or even better, chance for cure along with the maximum conservation of healthy tissue.

When managing skin cancer, MMS offers two distinct advantages: (1) 5-year cure rates as high as 99.9% [3–6], and (2) tissue conservation. Tissue conservation is maximized because arbitrary margins are not used. Tumors usually grow in an asymmetric fashion. Thus, excising a tumor with a 4-mm to 5-mm margin of clinically healthy skin is likely to result in the loss of a considerable amount of uninvolved tissue. With MMS, narrower margins (often 1–2 mm) are employed, which, when one combined with the precise localization and mapping of asymmetric microscopic tumor growth, makes it possible to maximally preserve healthy tissue. Conservation of healthy tissue is especially important when excising tumors of the head and neck, because this area is so important from a standpoint of cosmesis [7]. Preserving healthy tissue may allow for a less complex closure and less scarring. Tissue conservation also allows for maximal preservation of function when dealing with tumors located in or on critical areas such as an eyelid or digit.

The high cure rate offered by MMS not only gives the patient a greater peace of mind but allows the reconstructive surgeon to feel more comfortable in reconstructing complex defects that otherwise might be at high risk for recurrence. The primary reason that MMS ensures an extremely high cure rate is the manner in which the tissue is processed once it has been removed. Following routine excisions, the specimen often is “bread-loafed” (Fig. 1) into smaller specimens, some of which are selected for preparation for microscopic examination. With this approach, only a small percentage of the margins are examined [8]. Consequently, when dealing with tumors such as aggressive growth pattern basal cell carcinomas (BCCs), microscopic extensions of tumor may be missed, thereby resulting in falsely “clear margins” and a later recurrence. In contrast, MMS uses horizontal sections that also encompass the outer edges of the epidermis; thus, one is able to examine simultaneously the deep and lateral margins of the excised tissue in its entirety, making it unlikely that tumor will be missed (Fig. 2). Fig. 3 illustrates the steps involved when MMS is used to remove a cancer.
Advantages and disadvantages of MMS

Thirty years ago, patients often had to travel hundreds of miles to have MMS; however, today, it is much more readily available. MMS and the subsequent reconstruction usually are performed in an office setting under local anesthesia. This offers two distinct advantages: (1) it may extend operability to patients who are poor candidates for general anesthesia, and (2) it is cost effective when used appropriately [9]. Because the Mohs' surgeon serves as both surgeon and pathologist, there are no ancillary fees for pathology services. Moreover, because MMS usually is performed in an office setting under local anesthesia, there are no associated charges for use of a surgical facility or the services of an anesthesiologist. Finally, because of the high cure rate, it is unlikely that there will be a recurrence that would necessitate additional treatment and its associated costs.

Although the benefits of MMS are great, there also are some disadvantages with this procedure. When dealing with tumors with extensive subclinical spread, multiple surgical sessions may be required to render the patient tumor free. When this is the case, the procedure may become tedious, prolonged, and physically and emotionally exhausting for the patient. When a multidisciplinary approach is necessary to render the patient cancer free, it often requires general anesthesia. In this setting, the tumor usually is quite
large and it may be necessary to process and microscopically examine numerous specimens, which can be quite time consuming. Thus, it often is necessary to place a dressing over the wound, awaken the patient, and continue the surgery 1 to 2 days later under general anesthesia. Although this approach potentially increases perioperative risks, our experience to date has been favorable. The major advantages and disadvantages of MMS are outlined in Box 1.

Indications for MMS

Until recently, most patients were referred for MMS because they had a recurrent tumor. However, physicians are now better educated with regard to skin cancer and refer a significant number of high-risk tumors—for example, tumors located in anatomic areas noted for their high recurrence rate, subtypes of BCC noted for their high recurrence rate (eg, aggressive growth pattern BCC), and tumors noted for their local aggressiveness and high recurrence rate (eg, atypical fibroxanthoma [AFX], dermatofibrosarcoma protuberans [DFSP], and microcystic adnexal carcinoma [MAC]). A list of the indications for MMS are given in Box 2.

Recruent tumors often are ill defined; thus, it is difficult for the surgeon to determine what margins to use when excising the tumor. The radiation therapist and cryosurgeon face the same dilemma, in addition to trying to estimate the depth to which the radiation or freezing needs to extend. Electrodesiccation and curettage (ED&C) are ineffective because the curette cannot extract tumor embedded in scar tissue. Thus, it is not surprising that cure rates with routine modalities for recurrent tumors are significantly less than those reported for previously untreated tumors (Figs. 4 and 5) [10–15].

When dealing with a recurrent tumor, one may be faced with a large graft, flap, or scar, only a small portion of which is involved with tumor. In such cases, a decision must be made from the onset whether to remove the entire scar, graft, or flap or simply trace out the tumor and then stop. Some authors [16,17] have advocated always removing the entire graft, flap, or scar to avoid missing disconnected foci of tumor. My philosophy on this matter has been more flexible because by taking out the scar, graft, or flap initially, one may create an unnecessarily large defect. If it is a first recurrence and the tumor is confined to one edge of the old surgical site, I confine the MMS to that area. If the recurrence is more centrally located, or the scar, graft, or flap is small and removing it will not impact the reconstruction, I begin my surgery by removing it. If, at the completion of MMS, only a small amount of scar tissue, graft, or flap remains, I will remove it. Because clinically unapparent disconnected foci of tumor can exist, if the entire scar, flap, or graft is not removed, the defect should be managed conservatively—that is, healing by second intention or a skin graft. An exception to the above philosophy is tumors recurring after radiation therapy. Because disconnected foci are so likely, it is best to remove the entire irradiated area at the time of MMS [18].

Primary tumors sometimes may have indistinct borders. As with recurrent tumors, the surgeon, cryosurgeon, and radiation oncologist are faced with the same problem—that is, what margin of clinically normal skin to include in the area of treatment.

The histology of a BCC is extremely important in predicting the likelihood of a recurrence and in selecting the most appropriate treatment modality. Tumors that demonstrate an aggressive growth pattern cannot be managed by ED&C effectively [19] and because they usually are clinically ill defined, they are difficult to manage by cryosurgery, radiation therapy, or routine surgical excision (Fig. 6). Such BCCs may demonstrate significant subclinical spread with both wide and deep invasion, are more likely to recur after management by routine modalities, and often behave in a biologically aggressive manner. When managed by routine surgical excision, these tumors are more likely to show marginal involvement than are the clinically sharply demarcated nodular BCC (Fig. 7) [20]. Because of the inadequacies of routine pathology, one may also obtain false “clear margins,” only to have the patient later suffer a recurrence [21]. Histologically, these tumors are characterized by poor palisading of the tumor nests, infiltrating tumor strands, and small islands of tumor with poor palisading (micro-nodules) (Figs. 8 and 9). The stroma may or may not be sclerotic [21–27]. The morphea-type BCC is a clinical variant of the aggressive growth pattern BCC that has a sclerotic stroma and presents as an ivory white plaque, thus resembling morphea (Fig. 10). The sclerotic stroma precludes its management by ED&C [19,28], and radiation therapy has been reported to yield poor cosmesis [29]. As with all aggressive growth pattern BCCs, the morphea-type BCC may demonstrate significant subclinical spread, thus making routine surgical excision difficult (Fig. 11) [30,31].

Although a controversial entity, the metatypical BCC does appear to be an uncommon but distinct variant of BCC that often behaves locally in an aggressive manner and may be more likely than the common variants of BCC to metastasize (Figs. 12 and 13) [32–36]. These tumors often demonstrate
(1) The clinical aspect of the tumor is marked with a marking pen.

(2) A layer of clinically normal appearing tissue is circumferentially excised at a 45° angle.

(3) The layer of tissue is removed as smaller specimens. Lines are drawn on the skin with a marking pen or nibs are made to show the origin of the specimens. A map showing the origin of the specimens is drawn.

(4) The excised specimens may be further subdivided and colored with dyes for clarification purposes. The specimens are numbered and made a part of the map of the wound.

(5a) The specimen are then flipped upside down (i.e. deep side up).

(5b) The specimen are then flipped upside down (i.e. deep side up).

(6) Frozen horizontal sections are then cut, mounted on slides, stained and ready for histological interpretation.

(7) Each specimen is then placed on a chuck (deep side up) and embedded in embedding medium. The epidermal edge is "flipped-up" and brought into the same plane as the base of the specimen.

(8) Frozen horizontal sections are then cut, mounted on slides, stained and ready for histological examination.

(9) The exact area of residual tumor is marked on the Map's map.

(10) The residual cancer from Stage 1 is excised.

(11) The specimen is flipped upside down (deep side up), color coded, and placed on a chuck in embedding medium. The epidermis is then "flipped-up" and brought into the plane of the specimen.

(12) Frozen horizontal sections are cut, mounted on glass slides, stained and ready for histological examination.

(13) In this instance, all surgical margins are free of tumor and the patient is ready for reconstruction of the defect.
Box 1. Advantages and disadvantages of MMS

**Advantages**

Maximal cure rate
Maximal preservation of tissue
When done under local anesthesia, it extends operability to patients who are poor risks for general anesthesia
It is cost effective when used appropriately

**Disadvantages**

Requires the services of a specially trained physician and ancillary personnel, along with a specially equipped laboratory that limits availability
With difficult cases, the procedure may become tedious, prolonged, and emotionally and physically exhausting for the patient
If done under general anesthesia and there are numerous specimens to process and microscopically examine, it may be necessary to awaken the patient and complete the surgery (MMS or reconstruction) on another day(s)

extensive subclinical spread and, like the aggressive growth pattern BCCs, are best managed by MMS.

Another histologic variant of BCC that demonstrates a significant recurrence rate is superficial multicentric BCC (SMBCC) (Fig. 14) [26]. Although the name implies a multifocal origin, this is a misnomer. Reconstruction of these tumors reveals that what appears on routine histology to be separate foci of tumor actually are microscopic extensions that interconnect (Fig. 15) [37]. Although these tumors often can be eradicated by superficial means of destruction (ED&C, topical 5-fluorouracil, and cryosurgery), at times they may defy routine modes of management. Follicular involvement is not unusual with SMBCCs and renders superficial means of destruction ineffective. Subclinical spread at times may be significant, resulting either in "positive margins" or falsely "clear margins" when routinely excised [26]. Because of this, recurrent SMBCCs, large SMBCCs, and SMBCCs in anatomic areas at high risk for recurrence (eg, nose and ear) are best managed by MMS.

The field-fire BCC is characterized by the sequential appearance of one BCC after another in a confined anatomic area. Each BCC appears to represent a new primary. Eventually, such an area can become quite large and consists of numerous scars among which is intermingled BCCs. The pathogenesis of this entity is not clear. In some instances, it may represent a carcinogenic field effect, whereas in other cases, it may represent a recurrent BCC in which subclinical microscopic extensions were separated from the main tumor mass by the initial treatment. Each of these extensions then gives rise to what appears to be a new primary. Such tumors are best managed by MMS. Implicit in the definition of this concept is either a multifocal origin or the presence of noncontiguous tumor foci. Thus, conservative management of the resulting surgical defect (ie, allowing it to heal by second intention or grafting it) is mandatory.

Large and deeply invasive tumors are best managed by MMS because of the high recurrence rate associated with their treatment by standard modalities. This tendency to recur is due, at least in part, to unsuspected subclinical spread that has been well documented for tumors greater than 2 cm in diameter [19,30,38–40].

If a tumor has been excised routinely and the pathology report reveals involvement of the margins, a decision must be made regarding whether to reexcise the lesion or perform MMS. This decision should be based on the location and the histology of the lesion. If the lesion is located in a high-risk area for recurrence or in an area where maximum preservation of tissue is important, then MMS is the treatment of choice. The same is true when the histology of the lesion is associated with significant subclinical spread, as discussed previously.

Clinical observations over the years have taught us that there are certain anatomic areas of the head and neck that are associated with a higher-than-expected recurrence rate when tumors are managed by routine modalities. These areas include the embryonic fusion planes (eg, inner canthus, nasolabial fold, preauricular area, and retroauricular sulcus) [41–47] and the nasal ala [46,47], periorcular area [46–49], ear [42,43,46], scalp [50,51], and temple [52] (Figs. 16–19). In
Box 2. Indications for MMS

Clinically ill-defined tumors
Recurrent tumors
Morpheaform or aggressive growth pattern BCCs
Metatypical BCCs
Field-fire BCCs
Large (> 2 cm) or deeply penetrating tumors
Incompletely excised tumors
Tumors located in anatomic areas where maximal preservation of tissue or the highest chance of cure is mandatory (eg, periorbital area)
Perineural spread
Tumors located in anatomic areas noted for a high recurrence rate (eg, embryonic fusion planes, nose)
Syndromes associated with the development of multiple skin cancers (eg, basal cell nevus syndrome, xeroderma pigmentosum)
Tumors arising in scars, sinuses, and chronic ulcers
Young age
Tumors with a propensity for local recurrence, but a limited potential for metastases (eg, AFX, DFSP).

Fig. 5. Patient shown in Fig. 4 following completion of MMS. Tumor had extended between the articulating cartilages. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:277.)

general, tumors in these areas are managed best by MMS. Embryonic fusion planes that are vestiges of embryogenesis offer little resistance to the penetration and spread of tumor. Consequently, extensive subclinical spread may be observed. This accounts for the higher-than-expected recurrence rate for tumors treated in these areas by conventional modalities and explains why the resultant surgical defect from MMS often is much larger than anticipated. On the ear and

Fig. 6. Basal cell carcinoma with aggressive histologic growth pattern. Note flatness and ill-defined nature of the lesion. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:277.)

Fig. 4. Patient with recurrent BCC nose. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:277.)
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Fig. 4. Patient with recurrent BCC nose. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:277.)

Fig. 5. Patient shown in Fig. 4 following completion of MMS. Tumor head extended between the articulating cartilages. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:278.)

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nasal ala, tumors will penetrate to the perichondrium and then spread laterally, resulting in significant subclinical spread [41–43, 46, 47, 53]. On the nasal tip, tumors can dissect deeply between the cartilages. BCCs also can hide between the follicles or bud off of them and thus escape the curette. In the perinasal area, tumors can penetrate deeply and spread laterally, thus escaping the curette and defying other standard modalities of treatment. On the upper nose and in the external auditory canal, tumors can spread along the periosteum [46, 54].

On the scalp [45, 50, 51], the temple [46, 52], and malar region [46], tumor also can spread along the periosteum, escaping clinical detection. BCCs on the scalp may hide between the hair follicles or bud off of them, thereby rendering destruction by ED&C impossible. The vascularity of the scalp can interfere with the ability to achieve an adequate freeze with cryosurgery and to completely destroy a tumor.

The periorcular area is noted for its high recurrence rate for several reasons: (1) immidity on the part of the surgeon because of the cosmic and functional importance of structures in the area, (2) subclinical spread in the periorbital area along the orbital wall of the orbit (Figs. 20 and 21) [46], and (3) subclinical spread along the tarsal plate [46, 47]. Because treatment failure can have disastrous sequela (Fig. 22) and maximum preservation of tissue is mandatory, MMS is the ideal method to manage tumors in this area.

Some of the anatomic areas of the head and neck that are noted for their high recurrence rates are the same sites for which it is important to maximally preserve tissue uninvolved with tumor. These sites (nose and perinasal area, eyelids and periorcular area, lips and perioral area, and ears and pinnaauricular areas) are important both cosmetically and functionally. Thus, MMS with its unsurpassed cure rate and tissue conservation is the ideal way to manage tumors in these areas.

Perineural spread with skin cancer is not common, but when it occurs, it often forebodes extensive subclinical spread, the sacrifice of important nerves, and a high risk for recurrence (Fig. 23) [46, 55–58]. For these reasons, MMS is the treatment of choice for these tumors. These tumors may extend into cranial foramina and require a multidisciplinary approach for their eradication. Once spread to the central nervous system has occurred, these tumors may be unresectable and palliative radiation therapy may be all that one can offer the patient. As part of the preoperative evaluation of these patients, CT or MRI needs to be performed to detect extension into the foramina or to detect intracranial tumor. If intracranial tumor is present, a craniotomy should be performed first to determine whether the tumor is resectable [58]. If the tumor is unresectable, it makes no sense to subject the patient to extensive facial surgery if a cure is not possible. In carrying out MMS for a perineural tumor, the technique may need to be modified. If “skip areas” are suspected, an additional layer of tissue needs to be taken once a tumor-free wound is achieved [56]. However, in our experience, skip areas are rare. In tracing out the tumor, more generous specimens need to be taken to compensate for changes in the course of the nerve(s) and to include involved nerve branches coming off the major nerve trunk that is involved. Adjunctive radiation therapy sometimes is given postoperatively, especially when there is a question regarding the adequacy of tumor removal or extension into foramina. If there is concern about metastases to the regional nodes, the appropriate regional nodes and intervening lymphatics also would be irradiated.

When tumors (usually BCCs and SCCs) arise in scars, the entire scar should be removed, when feasible, to prevent it giving rise to yet another cancer. Because subclinical spread is unpredictable in this setting, MMS is the treatment of choice for such lesions.

Although BCCs that arise in the basal cell nevus syndrome can and should be managed by a variety of modalities, when one is dealing with a lesion that is at high risk for recurrence or is in a cosmetically and functionally important area where preservation of
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tissue is important as well as a high cure rate, then MMS is the treatment of choice. In managing the resultant Mohs' surgical defect, conservatism is mandatory. These wounds, if possible, should be allowed to heal by second intention. Flaps and grafts carry with them the risk of transferring tumor into a cancer-free wound. However, when faced with a decision, a graft taken from sun-protected skin would be preferable to a flap. Because these patients currently are doomed to getting new BCCs throughout their life, it is important to select a treatment modality that simultaneously ensures a high chance of cure and also minimizes tissue loss. In this setting, even routine elliptical surgical excisions sacrifice more tissue than they should. If routine surgical excisions are done, they should conform to the shape of the lesion and consideration should be given to allowing the wound to heal by second intention, especially if the lesion is not in
Fig. 8. Infiltrating BCC. (A) There is no central mass of basaloid cells. The tumor is composed of irregularly shaped islands and strands of basaloid cells dispersed in the stroma. The tumor is a plaque with a flat surface. Note extensions into the subcutaneous fat (hematoxylin-eosin, original magnification ×40). (B) The cellular aggregates have poorly developed palisading (hematoxylin-eosin, original magnification ×80). (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:279.)

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a cosmetically sensitive area. Similar considerations also are appropriate with regard to tumor management in patients with xeroderma pigmentosum.

MMS is the ideal way to manage tumors of the head and neck in younger patients, not only because of its high cure rate, but also because of its ability to conserve tissue that is important to achieve good cosmesis. A higher-than-expected recurrence rate for BCC in young women has been reported

This most likely is due, in part, to inadequate treatment because of cosmetic concerns on the part of the surgeon.

**Tumors amenable to MMS**

The tumors that have been managed successfully by MMS are listed in Box 3. With some of these...
Fig. 9. Micronodular BCC. Instead of large islands of basal cells, this variant is made up of small aggregates of cells (hematoxylin-eosin, original magnification ×80). (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:280.)

Fig. 10. Morphic BCC. Note the white plaque with telangiectasia. Lesion is extremely ill-defined. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:280.)

Fig. 11. Surgical defect after MMS for lesion in Fig. 10. Note the extensive subclinical spread. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:280.)

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**Tumors amenable to MMS**

The tumors that have been managed successfully by MMS are listed in Box 3. With some of these
tumors, the experience consists of a few reported cases, whereas in other instances (e.g., BCC and SCC), there is a vast experience. An in-depth discussion of each of these entities, is beyond the scope of this review; however, a few comments should be made.

When tracing out the microscopic extensions of some of the less common tumors, as well as melanoma, many Mohs’ surgeons will use frozen sections with or without immunostains. Some Mohs’ surgeons who employ frozen sections when treating melanoma will take an additional layer of tissue and submit it for permanent sections, once they feel they have achieved a tumor-free wound. Other Mohs’ surgeons employ permanent sections that can be processed overnight and microscopically examined the next day (“rush permaneniss” or “slow Mohs”). Those who employ frozen sections, especially for melanoma, argue that this approach allows the surgery to be completed in a day, whereas proponents of permanent sections point out the difficulty of interpreting frozen sections, especially for melanoma [60–65]. I prefer permanent sections for melanoma and other unusual tumors [66–68]. Although this approach may prolong the surgery, it has proved to be reliable and has not necessitated the taking of additional tissue that goes against one of the main tenets of MMS—that is, the preservation of healthy tissue.

For some of the more unusual tumors and melanoma, adjunctive treatment may be required in addition to removal of the primary lesion (e.g., a sentinel lymph node biopsy in patients with melanoma and Merkel cell carcinoma or postoperative irradiation in patients with Merkel cell carcinoma). As an example, MMS can be initiated at the same time that a sentinel lymph node biopsy is performed or initiated in an outpatient setting once the sentinel node biopsy has been performed.

Except for BCC and SCC, melanoma is the most common tumor managed by MMS. The use of MMS to manage melanomas is a controversial subject. Although many melanomas can be managed by routine surgical excision, there are times when MMS is the treatment of choice. The indications for MMS in the treatment of melanoma are listed in Box 4 [60–62]. The common thread that ties these indications together is that in these situations, subclinical spread is unpredictable and with routine surgical excision, there is a significant incidence of positive margins and recurrence, thus making MMS the treatment of choice. Based on the work of Zitelli and others [60–64], MMS offers cure rates for melanoma that are as high, if not higher, than those from routine surgical excision. MMS will fail in patients who subsequently develop satellite lesions and metastases, but no more so than will routine surgical excision.

**Management of the Mohs’ defect**

Over the past 30 years, there has been a dramatic change in the way the Mohs’ defect is managed. The replacement of the fixed tissue technique with the fresh tissue technique allowed for MMS to be completed in a single day and made immediate reconstruction possible. As experience has been gained, it has become obvious that MMS offers an extremely high cure rate. Consequently, there has been less need to delay reconstruction or let the wound heal by second intention or to apply a split-thickness graft as a temporizing measure. Despite the high cure rate with MMS, there still are times when the surgeon will be concerned about recurrence. In these situations, it is quite appropriate to employ one of the temporizing measures mentioned above.

Although healing by second intention is not as commonly employed as it once was, it sometimes is
tumors, the experience consists of a few reported cases, whereas in other instances (eg., BCC and SCC), there is a vast experience. An in-depth discussion of each of these entities, is beyond the scope of this review, however, a few comments should be made.

When tracing out the microscopic extensions of some of the less common tumors, as well as melanoma, many Mohs’ surgeons will use frozen sections with or without immunostains. Some Mohs’ surgeons who employ frozen sections when treating melanoma will take an additional layer of tissue and submit it for permanent sections, once they feel they have achieved a tumor-free wound. Other Mohs’ surgeons employ permanent sections that can be processed overnight and microscopically examined the next day (“rush permanents” or “slow Mohs”). Those who employ frozen sections, especially for melanoma, argue that this approach allows the surgery to be completed in a day, whereas proponents of permanent sections point out the difficulty of interpreting frozen sections, especially for melanoma [66-68]. I prefer permanent sections for melanoma and other unusual tumors [66-68]. Although this approach may prolong the surgery, it has proved to be reliable and has not necessitated the taking of additional tissue that goes against one of the main tenets of MMS – that is, the preservation of healthy tissue.

For some of the more unusual tumors and melanoma, adjunctive treatment may be required in addition to removal of the primary lesion (eg., a sentinel lymph node biopsy in patients with melanoma and Merkel cell carcinoma or postoperative irradiation in patients with Merkel cell carcinoma). As an example, MMS can be initiated at the same time that a sentinel lymph node biopsy is performed or initiated in an outpatient setting once the sentinel node biopsy has been performed.

Except for BCC and SCC, melanoma is the most common tumor managed by MMS. The use of MMS to manage melanomas is a controversial subject. Although many melanomas can be managed by routine surgical excision, there are times when MMS is the treatment of choice. The indications for MMS in the treatment of melanoma are listed in Box 4 [60-62]. The common thread that ties these indications together is that in these situations, subclinical spread is unpredictable and with routine surgical excision, there is a significant incidence of positive margins and recurrence, thus making MMS the treatment of choice. Based on the work of Zitelli and others [60-64], MMS offers cure rates for melanoma that are as high, if not higher, than those from routine surgical excision. MMS will fail in patients who subsequently develop satellite lesions and metastases, but no more so than will routine surgical excision.

**Management of the Mohs’ defect**

Over the past 30 years, there has been a dramatic change in the way the Mohs’ defect is managed. The replacement of the fixed tissue technique with the fresh tissue technique allowed for MMS to be completed in a single day and made immediate reconstruction possible. As experience has been gained, it has become obvious that MMS offers an extremely high cure rate. Consequently, there has been less need to delay reconstruction or let the wound heal by second intention or to apply a split-thickness graft as a temporizing measure. Despite the high cure rate with MMS, there still are times when the surgeon will be concerned about recurrence. In these situations, it is quite appropriate to employ one of the temporizing measures mentioned above.

Although healing by second intention is not as commonly employed as it once was, it sometimes is
the method of choice for managing the Mohs' defect. Wounds located on concave surfaces, and the temples, forehead, and upper nose usually heal with a good cosmetic outcome. Small superficial wounds of the distal nose also usually heal with a good cosmetic outcome; however, deeper wounds of the posterior ala and nasal tip may heal with a residual depression, as may the antihelix when cartilage has been removed. Wounds near free margins (eg, alar rim, eyelid, and vermilion border), when allowed to heal by second intention, may result in distortion (eg, alar rim notching or ectropion) [69,70].

Once the transition to the fresh tissue technique was made, Mohs' surgeons began to repair more of the defects they created. Because the repairs usually are performed in the office under local anesthesia, this adds to the cost effectiveness of MMS. Even complex reconstructions, such as paramedian forehead flaps, can be performed under local anesthesia with only the aid of oral sedation (Figs. 24–37). Although Mohs'
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Surgeons have become more adept at repairing their surgical defects, as noted below, there are times when they need to call on their surgical colleagues for help.

**Indications for a multidisciplinary approach**

There are many situations in which an interdisciplinary approach to manage a skin cancer may be necessary. The need for help—whether from the neurosurgeon, head and neck surgeon, reconstructive surgeon, or radiation oncologist—has been noted previously as it relates to perineural tumors. Although tumors invading bone can be traced out using the fixed tissue technique, if there is significant and deep bone involvement, it is sometimes more expedient to resect the involved bone under general anesthesia. At times, tumors can invade so deeply that they become inaccessible or the surgery cannot be completed under

Fig. 16. Patient with incompletely excised BCC of nasal-cheek sulcus. There had been three previous attempts at excision. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:283.)

Fig. 15. Superficial BCC. The periphery of the lesion is at the left. The shoulder of the tumor is composed of horizontally oriented nests of basal cells that are connected to the epidermis. The stroma encloses these islands. Evidence exists of regression in the central portion of the lesion, where there is fibrosis in the upper dermis and a dense host response of nonnuclear cells (hematoxylin-eosin, original magnification ×40). (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:282.)
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local anesthesia. The prime example would be a periocular tumor that has penetrated into the orbit so deeply that it is necessary to do an exenteration (see Fig. 22). If the tumor encroaches on a vital structure such as the carotid artery, it might not be wise or safe to continue the surgery alone in an office setting. If the parotid gland has been invaded and a parotidectomy is required, the help of a head and neck surgeon should be enlisted to avoid facial nerve disruption. Situations in which an interdisciplinary approach may be re-
local anesthesia. The prime example would be a periocular tumor that has penetrated into the orbit so deeply that it is necessary to do an exenteration (see Fig. 22). If the tumor encroaches on a vital structure such as the carotid artery, it might not be wise or safe to continue the surgery alone in an office setting. If the parotid gland has been invaded and a parotidectomy is required, the help of a head and neck surgeon should be enlisted to avoid facial nerve disruption. Situations in which an interdisciplinary approach may be re-

Fig. 17. Surgical defect following MMS in patient in Fig. 16. Note extensive subclinical spread that is seen frequently with lesions in this location. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:283.)

Fig. 18. Recurrent BCC of postauricular sulcus. Tumor was buried by prior treatment. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:284.)

Fig. 19. Surgical defect after MMS for lesion in Fig. 18. Note extensive subclinical spread. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:284.)

Fig. 20. Primary BCC of inner canthus. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:285.)
services of a surgeon who specializes in reconstruction or the defect is beyond the capability of the Mohs' surgeon. A cooperative effort between the Mohs' surgeon and reconstructive surgeon offers everyone the best of both worlds: the patient is offered the best chance of cure and optimal cosmesis; the Mohs' surgeon is confident that the patient feels that the best cosmetic outcome has been offered, and the reconstructive surgeon does not have to face a sometimes angry patient a year later who has developed a recurrence. Whether the patient with a tumor first presents to the Mohs' surgeon or reconstructive surgeon, this cooperative approach in management is encouraged.

When the reconstructive surgeon seeks the help of the Mohs' surgeon, the Mohs' surgeon anticipates the help of the reconstructive surgeon, or the patient requests in advance the services of a reconstructive surgeon, the case can be coordinated ahead of time so that the reconstruction is performed in the afternoon of the same day of or the day following MMS. However, required to manage a skin cancer are outlined in Box 5 [33,41–43,48,71–75].

When dealing with deeply invasive tumors that involve or encroach upon vital structures, it is ideal to obtain a preoperative CT scan or MRI to (1) determine the extent of the disease; (2) determine whether the tumor is resectable; (3) determine whether there is nodal involvement; and (4) develop a plan for a multidisciplinary approach, if so indicated (see Figs. 12 and 38–40). Unfortunately, especially with recurrent tumors, the full extent of the tumor may not be appreciated preoperatively. In such cases, it may be necessary for Mohs' surgeons to seek consultation once they have come to the end of their capabilities. In these situations, it is important for the consulting surgeon to work with the Mohs' surgeon and systematically trace out the tumor and not opt for an arbitrary wide resection with conventional frozen section sampling.

The most common reason that Mohs' surgeons call on their colleagues is the reconstruction of the Mohs' defect (Figs. 41–49). Although many Mohs' surgeons reconstruct the majority of their defects, there is variability from one Mohs' surgeon to the next. Moreover, there are times when the patient requests the

Fig. 21. Lesion shown in Fig. 20 required three stages of MMS. Tumor extended posteriorly along medial wall of the orbit. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:285.)

Fig. 22. Patient who was referred for MMS for a recurring BCC of the inner canthus. Clinically, the lesion preoperatively was comparable to that shown in Fig. 20. Ultimately, a multidisciplinary approach was required to render the patient tumor free. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:285.)
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Fig. 23. Neoplastic basal cells are present around nerve bundles in the dermis. Perineural extensions like these can go beyond the perceptible tumor margin (hematoxylin-eosin, original magnification ×200). (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:286.)

in many cases, it is difficult for the Mohs’ surgeon to know ahead of time if they will need the services of the reconstructive surgeon. In such cases, once the MMS has been completed, the patient can be seen in consultation by the reconstructive surgeon, wound care can be given, and the reconstruction can be scheduled. Delayed repairs have been commonplace at our institution for a number of years, and we have not found an increased incidence of complications or inferior cosmetic results.

Many of the tumors that are removed by Mohs’ surgeons are extensive and multiply recurrent, and many patients exhibit a carcinogenic field effect with many multiple primaries in a given anatomic area. Moreover, many of these patients have significant actinic damage and have a history of multiple carcinomas being removed. Thus, the proper planning and timing of the reconstruction is crucial.

With the high cure rate achievable with MMS, most defects can be reconstructed immediately and definitively. However, if there is concern about the completeness of tumor removal or the possibility of disconnected foci of tumor, or the patient has exhibited a carcinogenic field effect, definitive reconstruction should be delayed for 1 or 2 years and the area

<table>
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<th>Box 3. Tumors amenable to MMS</th>
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<td>BCC</td>
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<td>SCC</td>
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<td>Malignant fibrous histiocytoma</td>
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<td>Merkel cell carcinoma</td>
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<td>Sweat gland carcinomas (besides MAC and ACC)</td>
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<td>Sebaceous gland carcinoma</td>
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<td>Leiomyosarcoma</td>
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<td>Angiosarcoma</td>
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**Box 3. Tumors amenable to MMS**

- BCC
- SCC
- Melanoma
- AFX
- Malignant fibrous histiocytoma
- DFSP
- Extramammary Paget's disease
- Microcystic adnexal carcinoma (MAC)
- Adenoid cystic carcinoma (ACC)
- Merkel cell carcinoma
- Sweat gland carcinomas (besides MAC and ACC)
- Sebaceous gland carcinoma
- Leiomyosarcoma
- Malignant granular cell tumor
- Angiosarcoma
- Lymphoepithelial-like carcinoma
- Malignant tumors with hair follicle differentiation (eg, pilomatrix carcinoma, trichoblastic carcinoma)
- Epithelioid sarcoma
Box 4. Indications for MMS in the treatment of melanoma

- Melanomas > 2 cm in size
- Recurrent melanoma
- Melanomas of the head and neck (lentigo maligna)
- Melanomas located on acral areas and in the anogenital area (acral lentiginous melanoma)
- Ill-defined melanomas
- Desmoplastic melanoma
- Melanomas demonstrating perineural spread

These indications are drawn primarily from the work of Zitei and his co-workers [60–62].

(or areas) should be observed closely [76]. In the interim, the area can be allowed to heal by second intention or covered with a graft. Where appropriate, the patient can be fitted for a prosthesis while awaiting reconstruction.

One of the risks encountered in reconstructing a patient who has a history of multiple skin cancers with a flap or graft is transferring the tumor into the Mohs' defect or transcutting tumor at the donor site and delaying its detection. Thus, it is always important to scrutinize the donor site for a flap or graft and to biopsy any suspicious lesion before reconstructing the patient. Also, if additional tissue is removed at the time of reconstruction to create a cosmetic unit, it should be

Fig. 24. Patient with Mohs' defect of helix repaired with a transposition flap taken from the presubiculal area.

Fig. 25. Same patient as in Fig. 24, 6 weeks later.

Fig. 26. Same patient as in Fig. 24, 6 weeks later.
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sent for microscopic examination. We have found that many times tumor unrelated to the original tumor will be contained in these cosmetic units.

Limitations of MMS

As is true of any procedure, MMS has its limitations. Although MMS offers a high likelihood of cure, like all methods used to manage cancer, it is not 100% effective. Thus, at times, adjunctive therapy—usually irradiation—is required to increase the patient’s chance of cure. Radiation therapy is employed most commonly when there is extensive perineural spread or there is a question regarding the completeness of tumor removal. However, it also is used for certain tumors such as Merkel cell carcinoma.

The high cure rate achievable with MMS is based on the premise that tumor growth is contagious. If there are disconnected foci of tumor either because of prior treatment or because there are multiple subclinical tumors in a given area, then the patient may suffer a
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recurrence. In the case of multiple subclinical tumors, little can be done to compensate; however, if the tumor is recurrent or residual scar tissue or the remainder of the graft or flap from prior surgery can be removed and microscopically examined (see prior discussion above). Even in the setting of multiple primaries, MMS still is preferable to a blind excision.

Some tumors are so advanced by the time the patient presents for surgery, that they may be unresectable; in these cases, only palliative therapy is offered. To avoid discovering that the tumor is unresectable only after removing large amounts of tissue, it is important to carry out a thorough preoperative evaluation, including appropriate scans.
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Fig. 35. Patient whose Mohs' defect was repaired with a paramedian forehead flap.

At times the patient, especially an elderly one, may opt to settle for radiation therapy if it is deemed that total removal of their tumor may require extensive tissue removal that will leave them with a significant cosmetic or functional impairment. However, age should not be used as the sole criterion to determine whether a patient should undergo MMS. As already noted, MMS extends operability to patients who are considered at high risk for general anesthesia; unless the patient is extremely fragile and in poor health,

Box 5. Indications for a multidisciplinary approach

Perineural tumors that extend into foramina or intracranially
Tumors that have eroded deeply into or through bone (eg, into a sinus or through the skull)
Tumors that have invaded so deeply that they are no longer accessible or cannot be removed under local anesthesia or safely in an office setting (eg, tumors that have invaded deep into the orbit, thus requiring exenteration, or tumors lying in close proximity to the major vessels of the neck)
Tumors requiring postoperative irradiation
Mohs' defects requiring complex reconstruction

Fig. 36. Same patient as in Fig. 35, 6 months later.

Fig. 37. Same patient as in Fig. 35, 6 months later.
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- Mohs’ defects requiring complex reconstruction

Fig. 36. Same patient as in Fig. 35, 6 months later.

Fig. 37. Same patient as in Fig. 35, 6 months later.
Fig. 38. Computed coronal tomogram demonstrating erosion of the cheek (C) and malar bone, and invasion of the adjacent orbital floor (T) to involve the inferior rectus muscle with BCC. Note the optic nerve (arrow). (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:287.)

Fig. 39. The surgical defect included a modified maxillectomy, ethmoidectomy, and partial rhinectomy. The inferior orbital contents were removed by serial excision with microscopic examination by the Mohs' surgeon while other portions of the extirpation were being accomplished. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:288.)
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over routine surgical excision and pathologic examination [77]. At times, an intense inflammatory response may be present that makes microscopic interpretation of the tissue specimens more difficult. In general, this is less of a problem when dealing with BCC as opposed to other cutaneous neoplasms such as squamous cell carcinoma. This problem usually can be remedied simply by taking histologic sections from deeper within the tissue block.

When tumors invade deeply—particularly in certain anatomic areas (eg, the periorcular area)—access to and proper orientation of the removed tissue specimens may be difficult. Although a multidisciplinary approach under general anesthesia may solve part of the problem, precise mapping and orientation still may

they should be able to undergo MMS safely. Even when general anesthesia is required because of the need for a multidisciplinary approach, we have found that with careful preoperative preparation and good postoperative care, elderly patients in reasonably good health do well. All too often we have had to deal with elderly patients with extensive tumors because someone 5 years earlier felt that the patient was "too old" for definitive surgery. Now, 5 years later, the patient may be a poorer surgical risk and has a more advanced tumor.

For MMS to be successful the histologic specimens submitted for microscopic examination must be of superb quality; otherwise, there will be no advantage

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Fig. 40. View of defect (normally obscured with a prosthesis) 5 years postoperatively confirms preservation of the globe, supported in position by a split-thickness skin graft. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998,6:288.)

Fig. 41. Patient with extensive Mohs' defect following the removal of multiple recurrent BCCs of the central face. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998,6:289.)
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Fig. 42. Patient shown in Fig. 41 following reconstruction. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:289.)

Fig. 43. Mohs' defect of nose following the removal of a recurrent BCC. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:289.)

Fig. 44. Patient shown in Fig. 43 following reconstruction with a forehead flap. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:289.)

Fig. 45. Mohs' defect following removal of a recurrent BCC of the ear. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:289.)
Fig. 42. Patient shown in Fig. 41 following reconstruction. 

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Fig. 44. Patient shown in Fig. 43 following reconstruction with a forehead flap. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:289.)

Fig. 45. Mohs' defect following removal of a recurrent BCC of the ear. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:290.)
Fig. 46. Patient shown in Fig. 45 following reconstruction. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:290.)

Fig. 47. Frontal view of patient shown in Fig. 46. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:290.)
Fig. 46. Patient shown in Fig. 45 following reconstruction. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:290.)

Fig. 47. Frontal view of patient shown in Fig. 46. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:290.)
Fig. 48. Periocular defect following MMS for recurrent BCC. (From Lang P.Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:291.)

Fig. 49. Patients shown in Fig. 48 following reconstruction. (From Lang P. Mohs micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:291.)
Fig. 48. Periocular defect following MMS for recurrent BCC. (From Lang P. Moles micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:291.)

Fig. 49. Patients shown in Fig. 48 following reconstruction. (From Lang P. Moles micrographic surgery for basal cell carcinoma. Facial Plast Surg Clin North Am 1998;6:291.)
Box 6. Limitations of MMS

A patient may refuse surgery because of its required extensive nature and resultant cosmetic deformity or functional impairment.

The tumor may be unresectable.

Disconnected foci of tumor can result in a recurrence.

A brisk inflammatory response may interfere with the microscopic detection of tumor.

Poor-quality histologic preparations for microscopic examination can result in failure to detect tumor and lead to tumor recurrence.

Access to and proper orientation of removed tissue may be difficult when the tumor is located in certain anatomic areas and is deeply invasive.

Adjunctive therapy may be necessary to ensure a cure.

be problematic. Box 6 outlines some of the limitations of MMS.

Summary

In the past 30 years, MMS has become recognized as the treatment of choice for certain uncommon cutaneous neoplasms and for certain variants of BCC, squamous cell carcinoma, and melanoma. It offers an extremely high cure rate and maximally preserves healthy tissue, which often allows for preservation of function as well as an optimal cosmetic outcome. Because it is performed in an office setting under local anesthesia, MMS is a very cost-effective procedure and often extends operability to patients who are poor candidates for general anesthesia. In the past 30 years, MMS has evolved in a number of ways. The fixed tissue technique is uncommonly employed today. This makes the procedure less painful and faster and allows for immediate reconstruction. In addition, because statistics have demonstrated the reliability of MMS, it has become less necessary to delay definitive reconstruction or use temporizing measures. With experience and training, more Mohs’ surgeons have become adept at repairing the surgical defects they create; nevertheless, at times, it is necessary for the Mohs’ surgeon to call on his or her colleagues to reconstruct the Mohs’ defect or to assist in ridding patients of their cancer. At times, a multidisciplinary approach may provide the best care for patients. It also encourages collegiality and this has led to increasing respect for MMS by other surgical disciplines in the past 30 years.

References


