Clinical Review

Mohs' Micrographic Surgery of the Head and Neck

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Mohs' micrographic surgery, a method originally developed in the 1930s to remove contiguously spreading cutaneous cancers under precise microscopic control, has emerged as the most reliable method for removing certain primary, incompletely excised, and recurrent basal cell and squamous cell carcinomas. Indications for its use have expanded to include many other cutaneous and noncutaneous neoplasms. Usually done as an outpatient procedure and using local anesthesia, a layer of tissue is excised, mapped in relation to the site of removal, sectioned horizontally, and examined for the presence of residual tumor. This sequence is repeated, removing only tissue that contains residual tumor, until a margin completely free of cancer is reached. Extremely high cure rates are achieved, and surrounding tissue is maximally conserved for wound repair.

(Darmstadt GL, Steinman HK: Mohs' micrographic surgery of the head and neck. West J Med 1990 Feb; 152:153-158)

Skin cancer is the most common carcinoma in humans, with an annual incidence of more than 500,000 cases.[1] The most common types are the nonmelanoma carcinomas: basal cell carcinoma and, less frequently, squamous cell carcinoma. About 85% of these cutaneous neoplasms present on the head or neck. The majority are of extremely low metastatic potential, have well-defined borders, and are treated by excision, electrosurgery, cryosurgery, or irradiation with greater than 90% overall success (Table 1).[2] For treatment of the other, more difficult primary, recurrent, and incompletely excised skin carcinomas, Mohs' micrographic surgery gives the most reliable assurance of tumor-free margins regardless of tumor shape, size, depth, or invasion into bone or cartilage or along nerves or blood vessels. This procedure also conserves the maximum amount of normal tissue.

Historical Development

As a medical student in the mid-1930s, Frederick Mohs, MD, developed a method for removing cutaneous cancers under complete microscopic control. He began by examining the leukocytic reaction in normal and cancerous tissues of rats following the administration of various irritants and noted that a 20% solution of zinc chloride produced tissue fixation rather than just irritation. On removing the fixed tissue, he noted excellent preservation of its microscopic features.[3] He then conceived the idea of applying zinc chloride to various carcinomas, fixing them in situ, removing the cancer in layers, and microscopically examining each layer until a tumor-free plane was reached.[4] In the 1940s and 1950s there was much reluctance to accept Mohs' technique. The zinc chloride fixative seemed old-fashioned, bordering on quackery, and many surgeons were contemptuous of deliberately incising through known cancer and removing tissue piecemeal. But as Mohs produced high cure rates, preserved maximal amounts of adjacent normal tissue, and frequently salvaged patients who had been deemed inoperable, the value of the method began to be recognized.

In 1953 Mohs introduced a modification, the fresh-tissue technique, using a local anesthetic and no fixative, for cancer of the eyelid margins, where swelling and discomfort due to zinc chloride treatment was particularly troublesome.[5] In 1974 Tromovitch and Stegman provided significant impetus to the more widespread use of the fresh-tissue technique when they presented results from the first series of patients on whom this technique was used.[6] For the treatment of difficult basal cell carcinomas, this study showed a success rate similar to that with the fixed-tissue technique. Also, by omitting the zinc chloride treatment, several advantages were noted: the perioperative pain from tissue fixation in situ was relieved; several stages could be done in one day, allowing complete treatment in a few hours; and the tissue slough that occurred after the final stage of chemical fixation was eliminated, permitting immediate reconstruction of the surgical wound when indicated. Because of its many advantages, the fresh-tissue technique has replaced the fixed-tissue one, and most surgeons doing Mohs' technique now use the fresh-tissue technique exclusively.

Braun outlined some situations where the fixed-tissue method may still be advantageous[7]:

- Basal cell carcinomas invading bone, meninges, or brain;
- Squamous cell carcinomas invading deeply and around narrow spaces such as the external auditory canal;
- Lesions on highly vascular structures such as the penis; and
- Miscellaneous situations for the palliative removal of large, unresectable neoplasms.

Mohs also advocated using the fixed-tissue technique for malignant melanoma.[8] With the exception of melanoma, how-

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TABLE 1.—*Comparative Success in Treatment Methods Used for Basal Cell Carcinoma**

Treatment Method	Success Rate, %	Treatment Method	Success Rate, %
Electrosurgery	92.6-98.0	Radiation therapy	92.1-96.0
Excisional surgery	93.2-95.5	Mohs' surgery	97.4-99.1
Cryosurgery	94.0-97.0		

*From Swanson et al.[2]

ever, most surgeons using microscopic control think that even these cases can be handled with the fresh-tissue technique. Current research on melanoma will help clarify the role of Mohs' micrographic surgery in treating these tumors.

There are many synonyms for the technique, including chemosurgery and fixed-tissue technique, chemosurgery and fresh-tissue technique, microscopically controlled surgery, microcontrolled surgery, Mohs' microscopic surgery, Mohs' histographic surgery, Mohs' technique, Mohs' surgery, and the acronym MOHS (microscopically oriented histographic surgery). The nomenclature recommended by the American College of Mohs' Micrographic Surgery and Cutaneous Oncology is "Mohs' micrographic surgery."[9]

Surgical Technique

A surgeon begins by outlining the visible clinical margins of the lesion. After the induction of local anesthesia, the tumor is debulked with a scalpel or curette. Then, with the scalpel angled at approximately 45 degrees to the skin to create a beveling effect, a thin layer of tissue is removed 2 to 4 mm beyond the clinical margin of the tumor.

At the time of tissue removal, several steps are taken to ensure the proper orientation of the excised specimen. Before the specimen is completely detached, orientation marks are made on the excised tissue and at corresponding points on the surrounding skin using a scalpel, dyes, sutures, or staples. A map is drawn showing the relative size and shape of the specimen in relation to the area of the body from which it was taken. The tissue is cut on the orientation marks into pieces small enough to fit on a microtome cassette. Each of these smaller specimens is then numbered, turned over so that the undersurface is facing up, and color coded on the cut edges with stains. The position of the numbered specimens and the color coding schema are also indicated on the map.

A technician then carefully cuts from the undersurface serial frozen horizontal sections 5 to 7 μm thick. By first compressing the tissue flat and cutting horizontally across the bottom, the entire edge and undersurface of the excised tissue is sectioned. Horizontal sectioning is pivotal to Mohs' micrographic surgery, as it allows the complete peripheral and deep margins of the removed tissue to be examined. This has been superior to conventional vertical sectioning in showing all contiguous strands of tumor.[10,11] The sections are interpreted by the surgeon with or without the aid of a pathologist, and any remaining tumor foci are precisely located on the map and, therefore, also on the patient. An essential and unique feature of this technique is the active involvement of the surgeon in all phases of the procedure, including the orientation and processing of the surgical specimen, interpreting the histologic slides, and personally marking areas of residual tumor on the Mohs map. The Mohs' micrographic surgeon can then return to the patient and precisely remove only tissue where tumor is microscopically present.

The process can be repeated as often as necessary to extirpate tumor totally, removing only tissue with residual neoplasm and maximally preserving normal surrounding tissue. Because several stages can be completed in a day, and most tumors can be completely removed in three layers or less, all except the most advanced cancers can be removed in one day as an outpatient procedure. When a plane free of cancer is reached, the wound can be allowed to heal by second intention or may be closed primarily.[12,13]

Indications for Mohs' Micrographic Surgery

Mohs' micrographic surgery has become most widely accepted for the treatment of certain basal cell and squamous cell carcinomas. Because the procedure is labor-intensive, time-consuming, and expensive, and because most cutaneous carcinomas are successfully removed by routine methods (Table 1), Mohs' micrographic surgery should be used only for specific indications.

Basal Cell Carcinoma

Overall indications for the use of Mohs' micrographic surgical treatment of basal cell carcinoma include primary tumors in locations associated with an increased risk of local invasion and recurrence such as the midface and ear, tumors larger than 1 to 2 cm, or tumors with aggressive histopathologic or clinical characteristics indicative of a poor treatment response (Table 2). Incompletely excised and recurrent basal cell carcinomas are also generally best approached with the Mohs technique.

Primary basal cell carcinoma. Tumor location: Some

TABLE 2.—*Indications for Mohs' Micrographic Surgery*

- Basal cell carcinoma
  - Primary
    - Problem anatomic location, nose, eyes, ears, and embryonic fusion planes
      - High propensity for recurrence
      - Cosmetic or functional import or both
    - Aggressive histopathologic features
      - Morpheaform or sclerosing
      - Infiltrating
      - Metatypical
    - Size >2 cm diameter
    - Indistinct clinical margins
  - Incompletely excised
  - Recurrent
- Squamous cell carcinoma
  - Primary—same principles as above for basal cell carcinoma
  - Incompletely excised
  - Recurrent
  - Radiation-induced
  - Bowen's disease (gluteal cleft or vulvar)
- Other cutaneous lesions
  - Any locally invasive lesion with histologic features interpretable by frozen section
- Noncutaneous neoplasms (selected cases)
  - Parotid gland
  - Tongue
  - Oral cavity
  - Palate
  - Tonsillar pillars
  - Paranasal sinus

tissue and the position of the reference nicks were carefully diagrammed on an anatomic map. The surgical specimen was bisected, the cut edges were stained with dyes, and the size and shape of the cut sections and the color code for the marked edges were noted on the map (Figure 3). Horizontally oriented frozen sections were then taken along the entire flattened undersurface, ensuring that all surgical margins, including the epidermal edge, were visible for histologic review. The sections were stained with hematoxylin and eosin and reviewed by the surgeon.

Two foci of residual tumor were noted, and their positions within the tissue were carefully indicated on the map (Figure 4). The reference nicks in the patient's skin were used to relate the location of residual tumor on the map with the anatomic location in the surgical field. An additional layer was taken only around the residual tumor, and a second map was made of this excised specimen. The tissue was processed as before, and microscopic review revealed no residual tumor (Figure 5). The final tumor-free surgical defect measured 1.8 by 1.6 cm (Figure 6) and was allowed to heal by second intention.

Conclusions

Mohs' micrographic surgery offers meticulous marginal control for the treatment of a subgroup of basal cell and squamous cell carcinomas and may also be applicable for various other cutaneous and paracutaneous neoplasms. Its primary advantages are the conservation of normal surrounding tissues and structures, an extremely high cure rate, its use as an outpatient procedure, and a low operative risk. In most instances, a tumor-free defect can be reconstructed immediately. With better understanding of the Mohs technique and the indications for its use, an interdisciplinary team approach to selected cutaneous and paracutaneous tumors combining the surgeon doing the micrographic procedure and the head and neck surgeon, plastic surgeon, or ophthalmologist may become more commonplace.

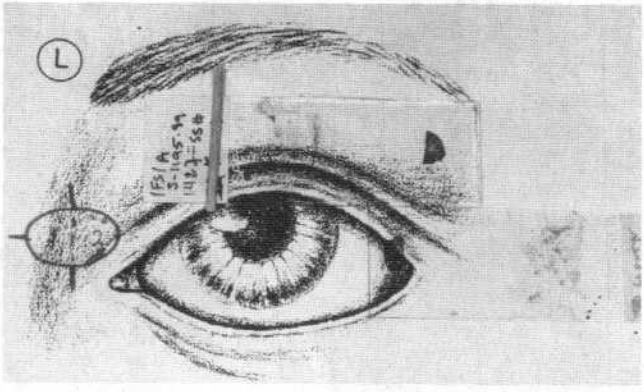

Figure 4.—The location of residual tumor is indicated on the map. The histologic slides, corresponding in size and shape to the sections on the map, are also shown.

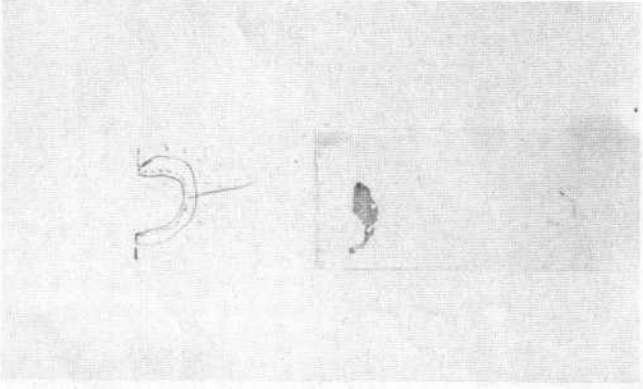

Figure 5.—The map of the second layer of the Mohs micrographic surgery and the corresponding histologic slide show clear margins. Note that only tissue around the residual tumor shown in Figure 4 was removed.

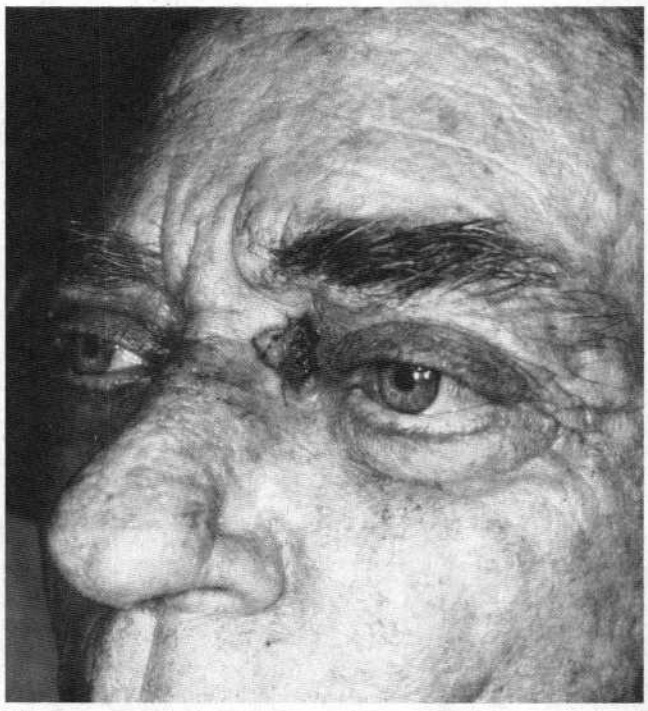

Figure 6.—The final defect is shown following two stages of Mohs' microscopically controlled surgery.

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of the head and neck, 25% of incompletely excised tumors recurred.[34] Mohs' micrographic surgery is an excellent follow-up treatment of these inadequately excised tumors that preserves the maximum amount of normal surrounding skin.

Recurrent basal cell carcinoma. A success rate of greater than 96% for treating recurrent basal cell carcinoma by micrographic surgery is well documented,* in contrast to lower success rates, often around 50%, for retreatment of these tumors by conventional means.[10,16,21,28,30,36,37] Therefore, when the Mohs microsurgical technique is available, it should be the treatment of choice for recurrent basal cell carcinomas.

Squamous Cell Carcinoma

Squamous cell and basal cell carcinomas behave and are treated in a similar manner. Routine, small, clinically less aggressive tumors that are actinically derived and are located in anatomic sites of low risk for metastasis or recurrence can be adequately treated using routine methods. As with basal cell carcinoma, however, those squamous cell carcinomas that occur in difficult anatomic sites, are large, or have an aggressive clinical nature are best handled using Mohs' techniques. Incompletely excised and recurrent tumors should also be treated using these techniques. Additional selected types and locations of squamous cell carcinoma can best be approached by Mohs' micrographic surgery, including tumors on previously irradiated skin[2] and Bowen's disease of the gluteal cleft or vulva.[13] Keratoacanthoma, although not a true squamous cell carcinoma, can grow in an aggressive manner in the central facial area; some advocate that these be treated like a squamous cell carcinoma, and, accordingly, many are manageable by Mohs' extirpation.[13]

Additional Applications of Mohs' Surgery

In general, any contiguously growing tumor that invades locally, recurs locally, and has histologic features amenable to frozen section interpretation can be treated using Mohs' surgery. Those that have been treated successfully using this technique include verrucous carcinoma, angioendothelioma, dermatofibrosarcoma protuberans, malignant fibrohistiocytoma, leiomyosarcoma, primary adenocystic carcinoma of the skin, primary Merkel cell carcinoma, meibomian gland carcinoma of the eyelid,[13] vulvar extramammary Paget's disease,[38] and penile erythroplasia of Queyrat.[32] Other indications for Mohs' surgery include certain cases of gangrene, warts, and ulcers.[13,28]

Mohs was the first to apply these techniques to noncutaneous neoplasms of the head and neck when he treated parotid tumors using the fixed-tissue technique.[28] Since then, these techniques have been used to treat squamous cell carcinomas of the floor of the mouth, the tongue, palate, tonsillar pillars, and the paranasal sinuses.[13,39] Conventional surgical treatment of these tumors is often debilitating, with loss of the mandible, tongue, or orbital structures. An interdisciplinary approach combining conventional surgical management of regional metastases with total microscopically controlled excision of the primary tumor is gaining acceptance.[2,17,40] This application of Mohs' micrographic surgery has resulted in preserving the mandible, tongue, and orbits of patients who would have lost these structures if approached by conventional methods.[13]

*References 10, 16, 19, 21, 28, 30, 33, 35, 36.

Report of a Case

The patient, a 62-year-old man, presented to his referring dermatologist with a slowly growing, painless, 0.6-cm pearl-colored papule of the left medial canthus; a similar lesion was also noted on the left cheek. The left cheek lesion, a basal cell carcinoma, was excised primarily with clear margins. The location of the medial canthal lesion, also a basal cell carcinoma, prompted referral for Mohs' surgery.

A presurgical examination showed a 0.6-cm by 0.8-cm healing scar of the left medial canthus (Figure 2). After the lesion was outlined, the skin was infiltrated with a local anesthetic (1.5 ml of a solution of 1% lidocaine hydrochloride with epinephrine at a dilution of 1:100,000), cleansed, and draped. A first layer of tissue was excised with a 2.5-mm margin. Before the specimen was completely excised, superficial reference nicks were made into both the specimen and adjacent skin. The location, size, and shape of the excised

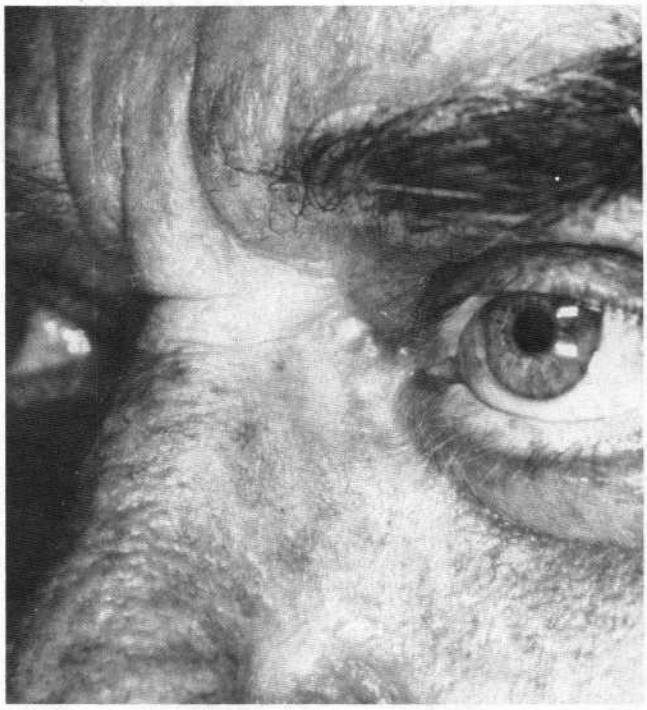

Figure 2.—A biopsy was taken of a basal cell carcinoma just medial and slightly superior to the left medial canthus.

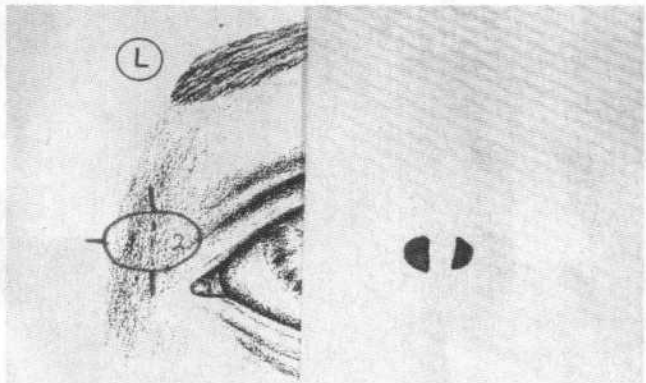

Figure 3.—A schematic map shows the anatomic location, size, and shape of the specimen; the position of the reference nicks; and the size, shape, and color coding of the edges of the cut sections of the specimen.

basal cell carcinomas send out silent, contiguous, subclinical extensions along planes of least resistance,[14] including fascial planes, periosteum, perichondrium, blood vessels, nerve sheaths, and the tarsal plate of the eyelid. Another important mode of spread is along embryonic fusion planes,[15] such as the junction of the nasal ala with the nasolabial fold, the preauricular area, especially the tragus, and the postauricular sulcus. Tissue planes at these sites may extend in a direction perpendicular to the surface of the skin, facilitating tumor invasion to unexpected depths.

Carcinomas in the central face tend to be more invasive, more destructive, more often recurrent, and more difficult to treat than similar tumors in other sites. Roenigk and associates analyzed the odds ratios of 239 recurrent basal cell carcinomas treated at the Cleveland Clinic Foundation from 1981 to 1983, providing an estimate of the relative risk of a recurrent basal cell cancer developing in a specific location compared with that of a tumor not in that location—that is, an odds ratio of 1.00 means there is an equal risk of recurrent tumor in a specific location compared with all other anatomic sites. Areas of particularly high risk of recurrence for basal cell carcinoma were concentrated in an H shape in the midfacial, auricular, and periauricular areas (Figure 1). Areas of specific concern are the junction of the ala with the nasolabial fold; the nasal ala; the nasal septum; the periauricular region, extending to the temple; the periorbital region, specifically the lower eyelid and the inner canthus; and certain scalp lesions.[16–19] The skin and subcutaneous tissue of both the midface and the ear are relatively thin and in close proximity to cartilage and bone, allowing the spread of tumor along the perichondrium and periosteum.[19,20] Robins noted that the preauricular area has the highest recurrence rate following Mohs' micrographic operation over any other anatomic site.[21] The ear can be particularly difficult to manage because of tracking of tumor down the external auditory canal, where it can gain access to the mastoid. The postauricular sulcus is an embryonic fusion plane in which tumor often grows in an aggressive manner. In the periorbital region, inner canthal tumors can often extend to and around the ethmoid sinuses; the resulting deep orbital spread of tumor can necessitate enucleation. The aggressive nature of basal cell carcinoma in the scalp is well documented, with occasional deep invasion and extension along the periosteal plane. Once the calvarium is penetrated, tumor can extend to involve the dura.[22]

Cosmetic and functional ramifications are the second reason that tumor location is particularly important. Key areas of cosmetic import include the nasal tip, the nasal ala, the upper lip, the helix, and the eyelids. A maximal preservation of normal tissue in these areas is necessary for proper postsurgical reconstruction.

Tumor histology: Tumors of standard histologic features, such as nodulocystic or adenoid, present little therapeutic challenge and can be handled routinely. Tumors with an aggressive histologic behavior, however, often warrant the more exacting treatment of Mohs' micrographic surgical technique.[16,23] These histologic subgroups include morpheaform or sclerosing basal cell carcinoma, superficial multicentric tumors, or aggressive metatypical basal cell carcinoma—previously referred to as basosquamous or keratinizing basal cell carcinoma. Greater subclinical extension,[24,25] particularly in the preauricular area,[24] and a higher rate of recurrence[19,23,26,27] have been documented with these tumor types, making Mohs' micrographic surgery the most appropriate initial therapeutic approach.

Tumor size: The success rate in treating basal cell carcinoma declines with increasing tumor size, especially when the tumor is larger than 1 to 2 cm.[16,18,21,28–33] Mohs reported a 99.8% cure rate for tumors less than 2 cm, 98.6% for tumors between 2 and 3 cm in size, and 90.5% for tumors greater than 3 cm in diameter[28]; the success rate declines more rapidly with increasing tumor size when routine methods are used. Therefore, basal cell carcinomas larger than 2 cm should be treated aggressively, and Mohs' micrographic operation should be considered.

Clinical characteristics: Most basal cell carcinomas are slow-growing and somewhat nodular in character, with distinct borders. There are subgroups, however, that are more rapidly growing, have ill-defined clinical borders, and are multicentric. These can be more difficult to treat and may be appropriate for Mohs' surgery.

Previous incomplete excision. If tumors with pathologically positive margins are watched clinically with no reexcision, high recurrence rates may result. Thomas found that incompletely excised tumors in the perinasal, periauricular, and periorbital regions recurred 82% of the time; on the rest

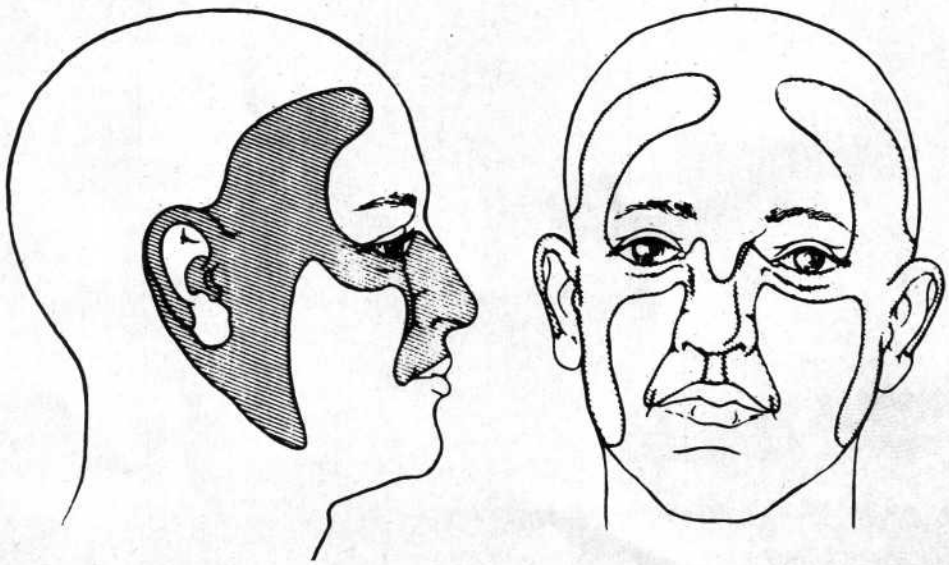

Figure 1.—The tumor location plays an important role in treating basal cell carcinoma. The shaded areas represent anatomic locations on the head and neck that warrant special consideration for Mohs' micrographic surgery (from Swanson et al[2]).

of the head and neck, 25% of incompletely excised tumors recurred.[34] Mohs' micrographic surgery is an excellent follow-up treatment of these inadequately excised tumors that preserves the maximum amount of normal surrounding skin.

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*References 10, 16, 19, 21, 28, 30, 33, 35, 36.

Report of a Case

The patient, a 62-year-old man, presented to his referring dermatologist with a slowly growing, painless, 0.6-cm pearl-colored papule of the left medial canthus; a similar lesion was also noted on the left cheek. The left cheek lesion, a basal cell carcinoma, was excised primarily with clear margins. The location of the medial canthal lesion, also a basal cell carcinoma, prompted referral for Mohs' surgery.

A presurgical examination showed a 0.6-cm by 0.8-cm healing scar of the left medial canthus (Figure 2). After the lesion was outlined, the skin was infiltrated with a local anesthetic (1.5 ml of a solution of 1% lidocaine hydrochloride with epinephrine at a dilution of 1:100,000), cleansed, and draped. A first layer of tissue was excised with a 2.5-mm margin. Before the specimen was completely excised, superficial reference nicks were made into both the specimen and adjacent skin. The location, size, and shape of the excised

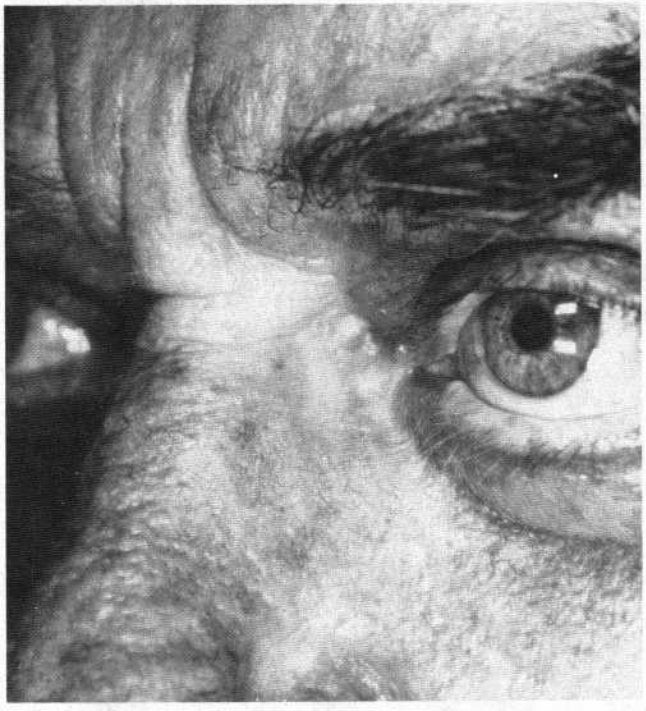

Figure 2.—A biopsy was taken of a basal cell carcinoma just medial and slightly superior to the left medial canthus.

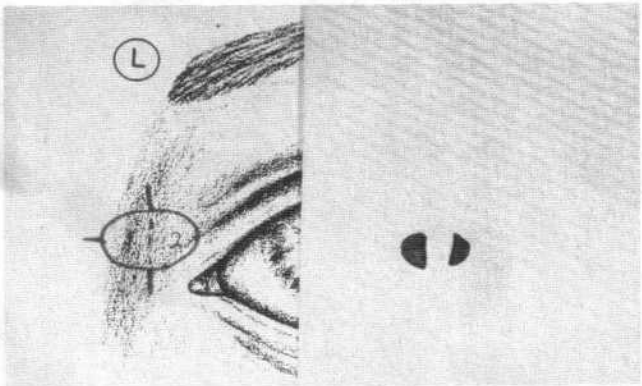

Figure 3.—A schematic map shows the anatomic location, size, and shape of the specimen; the position of the reference nicks; and the size, shape, and color coding of the edges of the cut sections of the specimen.

TABLE 1.—*Comparative Success in Treatment Methods Used for Basal Cell Carcinoma**

Treatment Method	Success Rate, %	Treatment Method	Success Rate, %
Electrosurgery	92.6-98.0	Radiation therapy	92.1-96.0
Excisional surgery	93.2-95.5	Mohs' surgery	97.4-99.1
Cryosurgery	94.0-97.0		

*From Swanson et al.[2]

ever, most surgeons using microscopic control think that even these cases can be handled with the fresh-tissue technique. Current research on melanoma will help clarify the role of Mohs' micrographic surgery in treating these tumors.

There are many synonyms for the technique, including chemosurgery and fixed-tissue technique, chemosurgery and fresh-tissue technique, microscopically controlled surgery, microcontrolled surgery, Mohs' microscopic surgery, Mohs' histographic surgery, Mohs' technique, Mohs' surgery, and the acronym MOHS (microscopically oriented histographic surgery). The nomenclature recommended by the American College of Mohs' Micrographic Surgery and Cutaneous Oncology is "Mohs' micrographic surgery."[9]

Surgical Technique

A surgeon begins by outlining the visible clinical margins of the lesion. After the induction of local anesthesia, the tumor is debulked with a scalpel or curette. Then, with the scalpel angled at approximately 45 degrees to the skin to create a beveling effect, a thin layer of tissue is removed 2 to 4 mm beyond the clinical margin of the tumor.

At the time of tissue removal, several steps are taken to ensure the proper orientation of the excised specimen. Before the specimen is completely detached, orientation marks are made on the excised tissue and at corresponding points on the surrounding skin using a scalpel, dyes, sutures, or staples. A map is drawn showing the relative size and shape of the specimen in relation to the area of the body from which it was taken. The tissue is cut on the orientation marks into pieces small enough to fit on a microtome cassette. Each of these smaller specimens is then numbered, turned over so that the undersurface is facing up, and color coded on the cut edges with stains. The position of the numbered specimens and the color coding schema are also indicated on the map.

A technician then carefully cuts from the undersurface serial frozen horizontal sections 5 to 7 μm thick. By first compressing the tissue flat and cutting horizontally across the bottom, the entire edge and undersurface of the excised tissue is sectioned. Horizontal sectioning is pivotal to Mohs' micrographic surgery, as it allows the complete peripheral and deep margins of the removed tissue to be examined. This has been superior to conventional vertical sectioning in showing all contiguous strands of tumor.[10,11] The sections are interpreted by the surgeon with or without the aid of a pathologist, and any remaining tumor foci are precisely located on the map and, therefore, also on the patient. An essential and unique feature of this technique is the active involvement of the surgeon in all phases of the procedure, including the orientation and processing of the surgical specimen, interpreting the histologic slides, and personally marking areas of residual tumor on the Mohs map. The Mohs' micrographic surgeon can then return to the patient and precisely remove only tissue where tumor is microscopically present.

The process can be repeated as often as necessary to extirpate tumor totally, removing only tissue with residual neoplasm and maximally preserving normal surrounding tissue. Because several stages can be completed in a day, and most tumors can be completely removed in three layers or less, all except the most advanced cancers can be removed in one day as an outpatient procedure. When a plane free of cancer is reached, the wound can be allowed to heal by second intention or may be closed primarily.[12,13]

Indications for Mohs' Micrographic Surgery

Mohs' micrographic surgery has become most widely accepted for the treatment of certain basal cell and squamous cell carcinomas. Because the procedure is labor-intensive, time-consuming, and expensive, and because most cutaneous carcinomas are successfully removed by routine methods (Table 1), Mohs' micrographic surgery should be used only for specific indications.

Basal Cell Carcinoma

Overall indications for the use of Mohs' micrographic surgical treatment of basal cell carcinoma include primary tumors in locations associated with an increased risk of local invasion and recurrence such as the midface and ear, tumors larger than 1 to 2 cm, or tumors with aggressive histopathologic or clinical characteristics indicative of a poor treatment response (Table 2). Incompletely excised and recurrent basal cell carcinomas are also generally best approached with the Mohs technique.

Primary basal cell carcinoma. Tumor location: Some

TABLE 2.—*Indications for Mohs' Micrographic Surgery*

- Basal cell carcinoma
  - Primary
    - Problem anatomic location, nose, eyes, ears, and embryonic fusion planes
      - High propensity for recurrence
      - Cosmetic or functional import or both
    - Aggressive histopathologic features
      - Morpheaform or sclerosing
      - Infiltrating
      - Metatypical
    - Size >2 cm diameter
    - Indistinct clinical margins
  - Incompletely excised
  - Recurrent
- Squamous cell carcinoma
  - Primary—same principles as above for basal cell carcinoma
  - Incompletely excised
  - Recurrent
  - Radiation-induced
  - Bowen's disease (gluteal cleft or vulvar)
- Other cutaneous lesions
  - Any locally invasive lesion with histologic features interpretable by frozen section
- Noncutaneous neoplasms (selected cases)
  - Parotid gland
  - Tongue
  - Oral cavity
  - Palate
  - Tonsillar pillars
  - Paranasal sinus

Clinical Review

Mohs' Micrographic Surgery of the Head and Neck

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Mohs' micrographic surgery, a method originally developed in the 1930s to remove contiguously spreading cutaneous cancers under precise microscopic control, has emerged as the most reliable method for removing certain primary, incompletely excised, and recurrent basal cell and squamous cell carcinomas. Indications for its use have expanded to include many other cutaneous and noncutaneous neoplasms. Usually done as an outpatient procedure and using local anesthesia, a layer of tissue is excised, mapped in relation to the site of removal, sectioned horizontally, and examined for the presence of residual tumor. This sequence is repeated, removing only tissue that contains residual tumor, until a margin completely free of cancer is reached. Extremely high cure rates are achieved, and surrounding tissue is maximally conserved for wound repair.

(Darmstadt GL, Steinman HK: Mohs' micrographic surgery of the head and neck. West J Med 1990 Feb; 152:153-158)

Skin cancer is the most common carcinoma in humans, with an annual incidence of more than 500,000 cases.[1] The most common types are the nonmelanoma carcinomas: basal cell carcinoma and, less frequently, squamous cell carcinoma. About 85% of these cutaneous neoplasms present on the head or neck. The majority are of extremely low metastatic potential, have well-defined borders, and are treated by excision, electrosurgery, cryosurgery, or irradiation with greater than 90% overall success (Table 1).[2] For treatment of the other, more difficult primary, recurrent, and incompletely excised skin carcinomas, Mohs' micrographic surgery gives the most reliable assurance of tumor-free margins regardless of tumor shape, size, depth, or invasion into bone or cartilage or along nerves or blood vessels. This procedure also conserves the maximum amount of normal tissue.

Historical Development

As a medical student in the mid-1930s, Frederick Mohs, MD, developed a method for removing cutaneous cancers under complete microscopic control. He began by examining the leukocytic reaction in normal and cancerous tissues of rats following the administration of various irritants and noted that a 20% solution of zinc chloride produced tissue fixation rather than just irritation. On removing the fixed tissue, he noted excellent preservation of its microscopic features.[3] He then conceived the idea of applying zinc chloride to various carcinomas, fixing them in situ, removing the cancer in layers, and microscopically examining each layer until a tumor-free plane was reached.[4] In the 1940s and 1950s there was much reluctance to accept Mohs' technique. The zinc chloride fixative seemed old-fashioned, bordering on quackery, and many surgeons were contemptuous of deliberately incising through known cancer and removing tissue piecemeal. But as Mohs produced high cure rates, preserved maximal amounts of adjacent normal tissue, and frequently salvaged patients who had been deemed inoperable, the value of the method began to be recognized.

In 1953 Mohs introduced a modification, the fresh-tissue technique, using a local anesthetic and no fixative, for cancer of the eyelid margins, where swelling and discomfort due to zinc chloride treatment was particularly troublesome.[5] In 1974 Tromovitch and Stegman provided significant impetus to the more widespread use of the fresh-tissue technique when they presented results from the first series of patients on whom this technique was used.[6] For the treatment of difficult basal cell carcinomas, this study showed a success rate similar to that with the fixed-tissue technique. Also, by omitting the zinc chloride treatment, several advantages were noted: the perioperative pain from tissue fixation in situ was relieved; several stages could be done in one day, allowing complete treatment in a few hours; and the tissue slough that occurred after the final stage of chemical fixation was eliminated, permitting immediate reconstruction of the surgical wound when indicated. Because of its many advantages, the fresh-tissue technique has replaced the fixed-tissue one, and most surgeons doing Mohs' technique now use the fresh-tissue technique exclusively.

Braun outlined some situations where the fixed-tissue method may still be advantageous[7]:

- Basal cell carcinomas invading bone, meninges, or brain;
- Squamous cell carcinomas invading deeply and around narrow spaces such as the external auditory canal;
- Lesions on highly vascular structures such as the penis; and
- Miscellaneous situations for the palliative removal of large, unresectable neoplasms.

Mohs also advocated using the fixed-tissue technique for malignant melanoma.[8] With the exception of melanoma, how-

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