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Mohs Micrographic Surgery Technique

Marko Vlačić[1*], Sandra Jelčić[2], Ivan Bešenji[3], Ivana Smiljanić[4]

[1]Clinic for Plastic and Reconstructive Surgery, University Clinical Center of Vojvodina, Novi Sad, Republic of Serbia
[2]Clinic for Physical Medicine and Rehabilitation, University Clinical Center of Vojvodina, Novi Sad, Republic of Serbia
[3]Institute for Cardiovascular Diseases of Vojvodina, Sremska Kamenica, Republic of Serbia
[4]Emergency Centre, University Clinical Center of Vojvodina, Novi Sad, Republic of Serbia
Email: *vlacic.marko@gmail.com

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Abstract

Mohs technique is a precise method for removing skin tumors that, during excision, preserves healthy tissue. Common skin tumors treated with this technique are squamous and basal cell carcinoma. The American College of Mohs Surgery has established guidelines for the use of the technique. Tumor localization, patient characteristics, and tumor features should be considered when assessing whether this technique is the right choice. It's useful in regions such as eyelids, lips and genitals. There are no absolute contraindications for the use of the Mohs technique. Before the surgery, a discussion with the patient should take place, a physical examination focusing on the tumor, and insight into the patient's medical records should be obtained. During the preoperative period, the nature of the tumor should be explained to the patient, and the entire procedure should be described. The surgical instruments, operating room, and laboratory for processing and examining tissue under microscope are necessary for performing the technique. The intervention is usually done under local anesthesia with protective margin of 1 - 5 mm. After excision, the specimen is processed and examined under a microscope. If microscopic examination reveals the presence of tumor tissue on the edges, the excision process is repeated until the tumor is completely removed. Wound infection, bleeding, hematomas, wound dehiscence, and the development of hypertrophic or keloid scars are complications. The Mohs technique is a precise procedure used for treating skin tumors, verifying the entire tumor margin and preserving the maximum amount of healthy tissue.

Subject Areas

Dermatology, Surgery, Surgical Specialties

Keywords

Mohs Micrographic Technique, Surgery, Skin Tumors

1. Introduction

The Mohs Micrographic Surgical Technique (MMST) is a precise method for removing skin tumors that, during tumor excision, spares healthy tissue. It is named in honor of the surgeon who developed the technique, Dr. Frederik Mohs. It is a surgical approach that offers high cure rates for various types of skin tumors, including basal cell carcinoma (BCC) and squamous cell carcinoma (SCC). The main advantage of the Mohs micrographic procedure is that it provides precise microscopic control of the entire tumor margin with maximal preservation of healthy tissue [1].

Dr. Frederik Mohs developed this technique in the 1930s. Originally called "chemosurgery", the technique involved the application of a chemical agent (zinc chloride) to fix the tumor lesion. After twenty four hours, the tumor would be excised and then examined under a microscope. The process would be repeated until the tumor tissue was completely removed [2] [3]. Over time, the Mohs procedure no longer involved tissue fixation with zinc chloride; instead, the tumor tissue would be frozen after excision and then cut horizontally in a cryostat microtome. This advancement improved the classical procedure in several aspects, allowing faster tissue processing (fifteen to thirty minutes), reducing patient discomfort, and contributing to greater preservation of healthy tissue [4].

MMST is suitable for skin tumors with a high recurrence rate and tumors on parts of the body where skin preservation is crucial [5] [6]. It is performed by circumferential incision with a thin protective margin around the tumor change, extending into the depth of clinically visible margins of the skin tumor. The sample is usually removed with a scalpel turned at a forty five degree angle to facilitate later tissue processing. The specimen is then rapidly frozen and processed in a cryostat microtome, allowing for quick tissue evaluation under a microscope within fifteen to thirty minutes. The processing in the cryostat microtome, or tissue cutting in the horizontal plane, enables almost the entire margin (peripheral and deep) of the excised tumor tissue to be examined under the microscope. The process is repeated until negative margins, *i.e.*, complete removal of tumor tissue, are achieved [1].

The research purpose was to illustrate the difference between the traditional method of tumor excision and histopathological verification and Mohs surgical technique, along with the subsequent histopathological processing of the excised tumor. Additionally, the goal was to highlight the advantages and benefits of Mohs micrographic surgical technique.

2. Indications

MMST is used in the treatment of numerous skin tumors. The decision to use this technique depends on the local status of the tumor, its size, location, histological characteristics, previous treatment modalities, the patient's immune system condition, and the presence of genetic syndromes [5]. The most common

skin tumors treated with this technique are SCC and BCC. In 2012, the American College of Mohs Surgery established guidelines for the appropriate use of the Mohs technique [7]. The document presents approximately two hundred seventy different clinical cases of skin tumors, classifying them as inappropriate, suitable in certain situations, and absolutely suitable for MMST. Tumors addressed in this document include BCC, SCC, lentigo maligna subtype of melanoma, melanoma in situ, Merkel cell carcinoma, leiomyosarcoma, eccrine, sebaceous, and mucinous gland carcinomas, extramammary Paget's disease, angiosarcoma, and dermatofibrosarcoma protuberans [7]. More invasive forms of skin melanoma are not covered in these guidelines due to the complexity of treatment [8].

The location of the tumor on the body, patient characteristics, and tumor features should be considered when evaluating whether MMST is the right treatment choice (**Table 1**) [7]. This technique allows for complete excision of tumors with unclear boundaries and should be considered for tumors with a high risk of recurrence or those whose treatment would result in functionally and aesthetically unsatisfactory outcomes [5]. The technique is particularly useful in certain body regions with crucial functions and unique anatomy, such as the eyelids, lips, genitalia, and nail areas. Skin tumors on the eyelids (five to ten percent), lips (three to four percent), penis (zero point five percent), vulva (one percent) and nail region (zero point three percent) are considered high-risk tumors for recurrence [7] [9]. BCC (ninety percent), sebaceous cell carcinomas (five percent) and SCC (four percent) are the most common skin tumors on the eyelids [9]. BCC and SCC are the most common lip skin tumors. SCC of the lips is particularly risky, with a metastasis rate of three to twenty percent [10]. In the eyelids and lips region, MMST records higher cure rates for skin tumors compared to classical surgical excision. Skin tumors in the genital region are mostly SCC (over ninety five percent). The recurrence rate of tumors in these regions is high, regardless of the therapeutic modality [9], but MMST is often used for tissue preservation, especially in males to avoid partial penectomy [11]. Nail region tumors are extremely rare, but when present, they are mostly SCC, followed by melanoma and BCC. The most documented data regarding the treatment of nail region tumors with MMST is for SCC, with a cure rate of ninety two to ninety five percent [12] [13]. For large and aggressive tumor forms, a multidisciplinary approach is necessary [8].

Although guidelines for the appropriate use of the Mohs technique determine the suitability of using this technique in specific cases, they do not compare the effectiveness of other treatment modalities or determine which treatment choice is more acceptable [7].

The choice of treatment technique ultimately depends on the clinical assessment of the physician, the individual patient's condition, and their decision. Guidelines for the appropriate use of the Mohs technique do not integrate treatment costs into suitability assessments; however, in these situations, costs are considered secondary when it comes to potential clinical improvement [7].

Table 1. Guidelines for the appropriate use of the Mohs technique.

Body region (**Figure 1**)	Area H (In this zone, MMST is highly indicated)	- Central part of the face, eyelids, eyebrows, nose, lips, chin, ears, and the area around the ears. - Genital region (perineal and perianal region). - Warts/areolas, hands, feet, joints, and nails.
	Area M	- Cheeks, forehead, occiput, neck, lower jaw. - Pre-tibial region.
	Area L	- Body and extremities (excluding the pretibial region, hands, feet, joints, and nails).
Patient characteristics	Immunocompromised	HIV, transplanted organs
	Genetic syndromes or disorders	Basal cell nevus syndrome, Xeroderma pigmentosum
	Previously irradiated skin	
	The history of skin tumors	
Characteristics of the tumor	The presence of tumor tissue at the margins in the previous excision of the tumor lesion	Positive margins in the previous excision
	Aggressive features of a tumor	BCC: Aggressive histological subtype, perineural spread of the tumor PCC: Poorly differentiated tumor (high degree of nuclear polymorphism, high mitotic index, or low degree of keratinization), perineural or perivascular spread of the tumor

3. Contraindications

There are no absolute contraindications for the use of MMST in patients considered suitable for surgery [1].

4. Preoperative Preparation

Before the operation, a discussion should be held with the patient [14]. During this conversation, it is necessary to examine the patient and review their medical documentation, provide an explanation to the patient about the nature of the tumor, prognosis, therapeutic options, and reconstructive possibilities, as well as postoperative wound care (including the need for limiting physical activity, the necessity for analgesic or other therapy), risk factors, and generally describe how the entire procedure should unfold. On the day of the operation, it is essential for the patient to sign an informed consent [15].

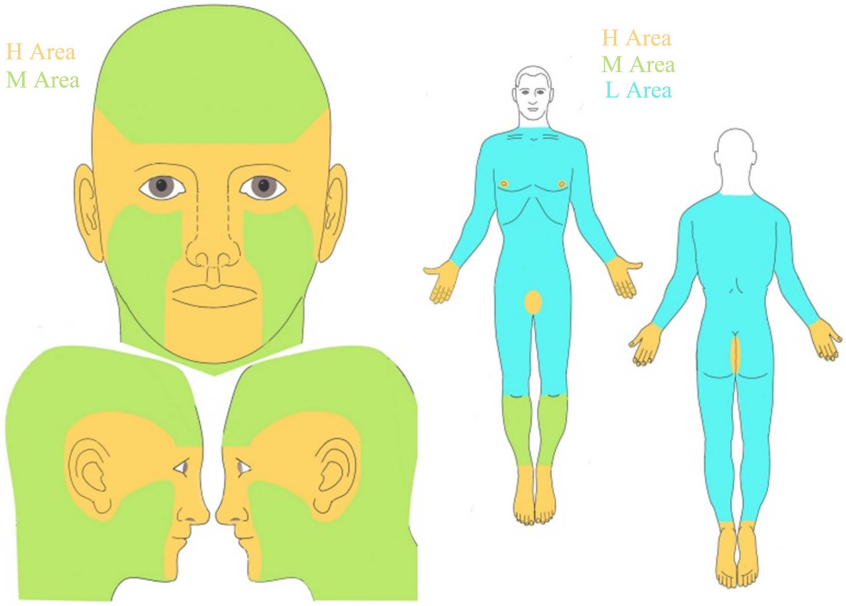


Figure 1. Division of body regions by areas. *H area—orange zone* (in this zone, MMST is highly indicated): central part of the face, eyelids, eyebrows, nose, lips, chin, ears, and the area around the ears, genital region (perineal and perianal region), warts/areolas, hands, feet, joints, and nails. *M area—green zone:* cheeks, forehead, occiput, neck, lower jaw, pre-tibial region. *L area—blue zone*: body and extremities (excluding the pretibial region, hands, feet, joints, and nails).

The review of medical documentation should focus on identifying comorbidities that could interfere with the surgical procedure, such as high blood pressure, diabetes, immunocompromised conditions, and hereditary blood clotting disorders [16] [17]. Before the operation, it is also necessary to assess whether the patient requires antibiotic prophylaxis, although for most patients treated with MMST, neither preoperative nor postoperative antibiotic use is required. According to some guidelines, patients with certain heart and joint diseases should undergo antibiotic prophylaxis before surgery to prevent bacterial endocarditis and joint infections [17]. It is also necessary to check whether the patient has hepatitis B, C, or HIV, given the risks associated with professional exposure to these diseases. Inquire about the patient's alcohol and cigarette consumption, as both factors contribute to the risk of perioperative complications [18] [19]. Pay attention to whether the patient has a pacemaker to ensure the safe use of an electric cautery for stopping bleeding [20]. Also, note allergies to medications and other medical products [8].

Some of the medications and supplements the patient may be taking can contribute to the risk of increased bleeding. Oral anticoagulant drugs such as warfarin, acenocoumarol, or antiplatelet drugs like aspirin, clopidogrel, or nonsteroidal anti-inflammatory drugs (NSAIDs) can increase the risk of bleeding. Some herbal dietary supplements that can increase intra- and postoperative bleeding include ginko biloba, garlic, ginger, and others [21] [22]. For patients at increased risk of bleeding, it is necessary to check platelet count, prothrombin

time, and activated partial thromboplastin time to safely perform the surgical intervention. If the platelet count is below fifty thousand it is considered a relative contraindication for surgery. The current consensus is that patients should not stop anticoagulant or antiplatelet therapy because the risk of thromboembolic complications outweighs the risk of bleeding [23]. It is advisable to discontinue the use of aspirin or NSAIDs seven to ten days before the intervention [24]. There are situations where reducing or discontinuing oral anticoagulant therapy is necessary, and in such cases, existing therapy is best replaced with low molecular weight heparin preparations [25].

After the discussion and review of medical documentation, a physical examination is conducted with a special focus on the tumor lesion. Most patients undergo a biopsy of the lesion before the actual Mohs procedure to histopathologically confirm that the change is of tumor origin. In some cases, where the tumor change is highly likely to be malignant, a biopsy with histopathological verification can be performed on the day of the Mohs technique surgery. The tumor change should be photographed, and its boundaries measured before performing MMST [26]. The histopathological findings of the biopsy should be reviewed, and in cases of uncertainty about the diagnosis and histological features, the surgeon using MMST should examine the original molds before the intervention [27]. As part of the physical examination, regional lymph nodes should be palpated, and surrounding anatomical structures examined. Large tumor lesions may require additional radiological diagnostics, such as ultrasound, computed tomography, lymphoscintigraphy, magnetic resonance, or positron emission tomography. More complex cases require a multidisciplinary approach [28].

On the day of the operation, vital signs should be measured as part of the physical examination. It is not possible to perform a surgical procedure in areas where there is an active skin infection [8].

Some patients may require sedatives before surgery, such as benzodiazepine sedatives and hypnotics like bromazepam or midazolam. During the execution of MMST, midazolam has been found to induce anterograde amnesia and drowsiness, without reported adverse effects. The patient must sign an informed consent before administering sedative medications [29].

5. Technique

To perform the Mohs Micrographic Surgical Technique, surgical instruments, an operating room, and a laboratory for processing and examining tissue under a microscope are necessary. The operating room should have good lighting and an adjustable operating table to ensure adequate visualization and easy access to the tumor. The required surgical instruments for the procedure include a scalpel, forceps, scissors, gauze, and an electrocautery device. The laboratory consists of a microtome where the frozen tissue is cut into very thin slices placed on glass slides. These slides are then either processed in automated staining machines or manually stained with various reagents. The final processed specimens are ready

for examination under a light microscope to determine if tumor tissue is still present at the edges of the cut specimen [1].

The technique is typically performed under local anesthesia in an outpatient setting where sterile conditions are required [29].

The first step in MMST is identifying the site of the previous biopsy, which can be challenging, especially if some time has passed between the biopsy and the Mohs excision, as the lesion may be obscured by a scar which can be from different etiology [30]. Additional techniques are sometimes used to aid in identifying the biopsy site, such as photographs taken by patients, fluorescent tattoos visible under ultraviolet light, subcutaneous bubbles formed during biopsy, re-biopsy, or contacting the physician who performed the biopsy. After confirming the biopsy site, the patient is placed in a supine position. The edges of the clinically evident tumor lesion are marked with a marker all around the circumference, dimensions are measured, and photographs are taken before the application of local anesthesia, as anesthesia can distort the lesion and compromise its edges. The operative field is then cleaned, and a local anesthetic solution is infiltrated [31].

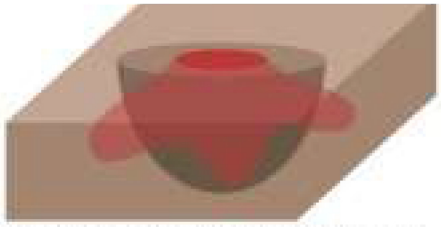
Following local anesthesia, the surgeon may use a curette to delineate the surrounding healthy skin from the tumor lesion. Lesions such as BCC and SCC are often more fragile than the surrounding healthy skin, and curettage can help identify tumor edges not clinically visible. Although curettage may increase the size of the initial tumor lesion, several studies have shown that this technique reduces the need for additional Mohs excisions [32] [33] [34].

A protective margin of 1 - 5 mm, depending on the tumor type, is drawn around the clinically visible tumor lesion. Local anesthetic is infiltrated before making an incision around the lesion. The incision is made at a 45-degree angle, facilitating later tissue processing, and extends to the clinically visible edges of the tumor. Hemostasis is then achieved, usually using an electric cautery. The patient is dressed, and the specimen processing takes place over the next thirty to one hundered twenty minutes [8].

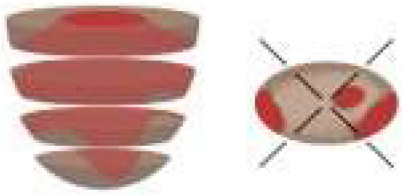
The processed specimen is flattened, *i.e.*, the epidermal edge is in the same horizontal plane as the bottom edge of the specimen. As mentioned earlier, excising tissue at an oblique angle facilitates this process. The tissue is then cut horizontally into thin slices. This approach provides almost complete visualization of all margins (peripheral and deep) of the tumor under the microscope, as opposed to classical vertical tissue excision and processing with vertical cuts, where only a small portion of tumor edges is visualized [35] (**Figure 2**). If microscopic examination reveals tumor tissue on any of the edges, a repeat excision of the skin where the margin is positive is performed. The process is repeated until all margins are negative, *i.e.*, the tumor tissue is completely removed while preserving healthy tissue maximally (**Figure 3**). Once the tumor is excised, various techniques are used to close the resulting defect, ranging from direct closure of the defect, the use of local skin flaps and skin grafts, to spontaneous healing of the defect per secundam [36].

MMST	Traditional excision and tissue processing technique

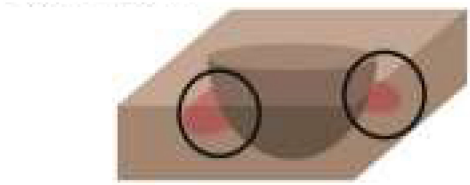
Skin tumors are often found beyond clinically visible boundaries. The tumor (marked in red) is first excised (in black) with an adequate safety margin.



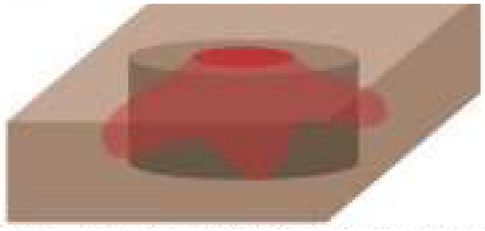
a) Excision of the tumor in MMHT is performed at a curved angle to facilitate easier tissue processing later on



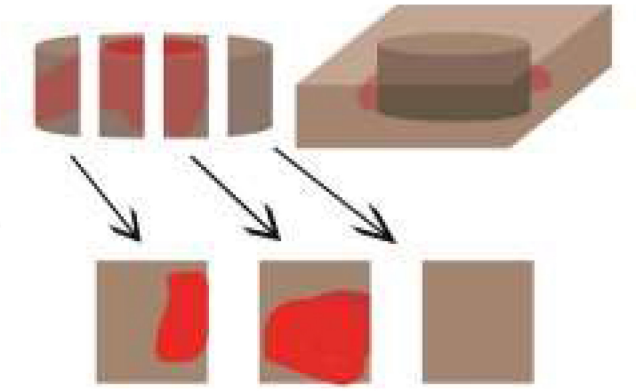
b) The Mohs procedure involves horizontal cuts during tissue processing for microscopic analysis, enabling visibility of the entire tumor margin. Positive margins are easily identified, as shown in the image above



c) When determining positive margins, additional layers of tissue where the tumor remains are excised, allowing for high cure rates. This technique provides preservation of healthy skin unaffected by the tumor, aiming for smaller and aesthetically acceptable scars, as well as greater possibilities for reconstruction



a) Classical surgical excision is performed at a ninety degree angle. The tissue is then cut into equal parts through vertical incisions, which are subsequently examined under a microscope



b) Examples of errors in this tissue processing method include

c) In this technique, the tissue is processed with vertical cuts. Typically, less thanone percent of the margin is evaluated. This can result in higher error rates during the processing and microscopic examination of tumor tissue

Figure 2. Comparison of MMST and accompanying tissue processing with traditional excision and tissue processing technique.

6. Complications

A large prospective study that investigated over 20,000 patients undergoing Mohs Micrographic Surgery Technique (MMST) in multiple healthcare centers found a complication rate of approximately 0.72%, with a rate of serious complications around 0.02%, and no lethal outcomes [37]. Postoperative complications,

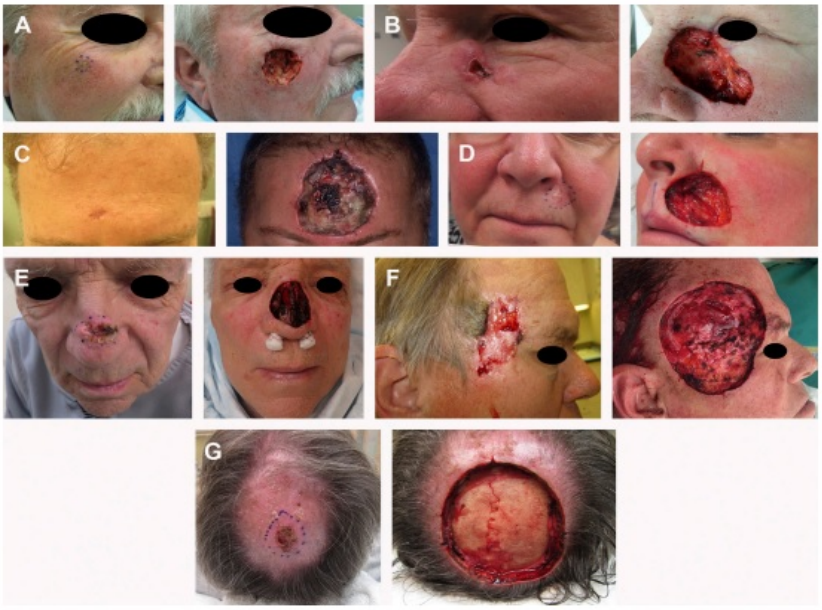


Figure 3. Images of tumor lesions preoperatively and images of the definitive surgical defect after excision of the tumor lesion using Mohs Micrographic Surgery (MMS). (A) Squamous cell carcinoma (SCC) in the region of the right cheek with perineural spread. (B) Basal cell carcinoma (BCC) in the lower left eyelid region. (C) Dermatofibrosarcoma in the frontal region. (D) Sebaceous gland carcinoma in the region of the left nasolabial fold. (E) Squamous cell carcinoma (SCC) on the dorsum of the nose. (F) Basal cell carcinoma (BCC) in the temporal region on the right side. (G) Squamous cell carcinoma (SCC) in the occipital region.

if they occur, are often more related to the reconstructive aspect rather than the MMST itself. Some reported complications include wound infection, bleeding, hematoma, wound dehiscence, tissue necrosis, and the development of hypertrophic or keloid scars. These risks can be minimized through meticulous surgical technique and proper wound care [8].

7. Conclusion

In practice, it is shown that MMST is a valuable tool for achieving high cure rates, especially in cases where tumor boundaries are unclear or when preserving healthy tissue is essential. The technique's versatility and suitability for various skin tumors, along with its meticulous approach to microscopic control, position it as a preferred method for surgeons. Continued research and clinical experience will likely contribute to further refinement and widespread acceptance of MMST as a standard in skin tumor excision.

Conflicts of Interest

The authors declare no conflicts of interest.

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