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MOHS MICROGRAPHIC SURGERY IN NON-MELANOMA SKIN CANCER

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REWIEW ARTICLE

Abstract

Mohs Micrographic Surgery (MMS) is an advanced technique used to treat non- melanoma skin cancers, especially basal cell carcinoma and squamous cell carcinoma. This study presents a literature review on the application of MMS, highlighting its indications, benefits, limitations and recent advances. MMS offers high cure rates, often over 99% for primary tumors, while preserving as much healthy tissue as possible, making it the gold standard for lesions in critical areas such as the face, hands and genitals. The method combines precise tumor excision with intraoperative microscopic mapping, guaranteeing cancer cell-free margins and reducing the need for reinterventions. The review included studies addressing clinical outcomes, efficacy and comparison with other therapeutic modalities. The results confirm the superiority of MMS in high-risk, recurrent tumors or those with poorly defined margins, as well as its effectiveness in reducing complications and preserving functionality and aesthetics. However, limitations include the need for specialized infrastructure and trained staff, restricting its widespread implementation. It is concluded that MMS is a safe and effective approach, and it is essential to encourage its dissemination and to carry out new research to optimize its clinical application.

Keywords: Mohs Micrographic Surgery; Non-Melanoma Skin Cancer; Basal Cell Carcinoma; Squamous Cell Carcinoma; Oncological Treatment; Advanced Surgical Techniques.

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INTRODUCTION

Non-melanoma skin cancer (NMSC) is the most common malignant neoplasm in the world population and represents a significant public health concern. According to the World Health Organization (WHO), its prevalence continues to increase globally, especially in populations with high prolonged sun exposure and risk factors such as light phototype and immunosuppression (World Health Organization, 2021). Among the therapeutic options available, Mohs Micrographic Surgery (MMS) stands out as the gold standard for the treatment of NMSC in critical anatomical areas and tumors with aggressive or recurrent characteristics (Aasi et al., 2014).

The Mohs technique, developed in the 1930s by Frederic Mohs, is a surgical approach that combines precise excision of the tumor with intraoperative microscopic analysis of the margins (Mohs, 1941). This methodology makes it possible to achieve high cure rates, often exceeding 99% in primary cases, while preserving as much adjacent healthy tissue as possible, and is especially useful in regions such as the face, hands and genitals (Bader et al., 2020). In addition, the ability to map and identify microscopic tumor cells in real time reduces the need for additional procedures and guarantees disease- free surgical margins (Bichakjian et al., 2016).

The role of MMS is also fundamental in the management of recurrent tumors or tumors with poorly defined margins, in which conventional surgical techniques may be insufficient. Comparative studies show that the technique is more effective than other methods, such as standard excision and electrosurgery, particularly in high-risk tumors (Jensen et al., 2018). However, the implementation of this technique requires specific infrastructure and trained staff, making its availability limited to specialized centers (Lang et al., 2021).

This article explores the technical and clinical aspects of Mohs Micrographic Surgery, covering its indications, stages, advantages and limitations. Current evidence on the efficacy and long-term outcomes of this approach in the treatment of non-melanoma skin cancer will also be discussed.

METHODOLOGY

This literature review article was conducted following a systematic approach to identify, select, and analyze relevant studies on MMS in the treatment of non-melanoma skin cancer (NMSC). The methodological steps followed the following criteria:

Search strategy

A comprehensive search was carried out in recognized scientific databases, including **PubMed**, **Scopus**, **Web of Science**, and **SciELO**, to ensure that relevant publications were identified. Search terms were defined based on standardized descriptors (MeSH terms) and included combinations such as:

- "Mohs micrographic surgery
- "Non-melanoma skin cancer
- "Basal cell carcinoma
- "Squamous cell carcinoma
- "Skin cancer treatment".

The filters applied limited the studies to those published in English, Portuguese and Spanish.

Inclusion and exclusion criteria

Specific criteria were defined for the inclusion of studies in the review:

- **Inclusion**:
  - Original articles, systematic reviews and meta-analyses related to MMC in NMSC. Studies that addressed efficacy, clinical outcomes, surgical technique or recent advances.
  - Publications with clear methodology and statistically significant data.
- **Exclusion**:
  - Case reports, letters to the editor and studies with insufficient samples.
  - Studies focused on melanoma or other types of skin cancer.
  - Duplicate articles between different databases.

Selection process

The selection was made in three stages:

1. **Initial screening**: Reading of titles and abstracts to identify potentially eligible studies.

2. **Detailed assessment**: Thorough reading of the selected articles to check their suitability for the inclusion criteria.
3. **Final inclusion**: Studies that met the criteria were included in the analysis and discussion of the review.

Data Extraction and Analysis

The data was extracted in a standardized way, covering:

- General information: authors, year of publication, place of study.
- Description of the methodology: type of study, sample and techniques used.
- Main results: cure rates, recurrence, complications and tissue preservation.
- Discussion of recent advances and limitations.

The data was summarized in tables and narratives, organized according to specific themes, such as the efficacy of MMC, benefits in critical anatomical areas, and comparison with other therapeutic modalities.

Quality assessment

The quality of the studies was assessed using appropriate tools, such as the **PRISMA scale** for systematic reviews for original studies, ensuring the inclusion of publications of high relevance and methodological robustness.

Summary of results

The data extracted was organized into thematic categories to facilitate comparative analysis and the identification of trends and gaps in knowledge about MMC. The findings were presented in tables, graphs and narratives, highlighting the most relevant contributions to clinical practice. This methodological approach guarantees transparency, replicability and scientific rigor in the construction of this literature review, providing a comprehensive and critical overview of Mohs Micrographic Surgery in the management of non- melanoma skin cancer.

RESULTS AND DISCUSSION

Initial Assessment and Planning

The initial assessment and planning stage in Mohs Micrographic Surgery (MMS) is fundamental to ensuring successful treatment and minimizing complications. The preoperative consultation plays an essential role in this process, allowing the

dermatologist or surgeon to assess the patient in detail, reviewing the medical history, including comorbidities, medication use and previous history of skin cancer. This comprehensive analysis is crucial in determining the patient's eligibility for MMS, since certain conditions, such as bleeding disorders or difficulties in healing, can influence the choice of surgical technique (Aasi et al., 2014; Bichakjian et al., 2016).

Indications for MMS include tumors located in critical anatomical areas such as the face, hands, feet and genitals, where the preservation of healthy tissue is essential to maintain functionality and aesthetics. In addition, the technique is recommended for neoplasms with ill-defined margins, tumors that have recurred after previous treatments or those with aggressive growth patterns, such as the scleroderma and infiltrative subtypes of basal cell carcinoma (Bader et al., 2020; Lang et al., 2021).

The choice of MMS in such cases is justified by its ability to completely remove the tumor while minimizing the excision of healthy tissue.

Surgical planning involves precise marking of the tumor site to guide excision and mapping during the procedure. The surgeon explains to the patient in detail what the process will be like, including the possibility of multiple intraoperative stages to ensure tumor cell-free margins. This stage is also important for establishing realistic expectations about the aesthetic and functional results, promoting greater adherence to treatment and reducing patient anxiety (Jensen et al., 2018; Bichakjian et al., 2016).

Therefore, initial assessment and proper planning are fundamental pillars for the success of Mohs Micrographic Surgery, ensuring that the technique is applied accurately and with optimized results for the patient.

Mohs Surgery: Local Anesthesia

The use of local anesthesia in Mohs Micrographic Surgery (MMS) is an essential practice to ensure patient comfort during the procedure. Local anesthesia is administered through injections containing anesthetic agents such as lidocaine, often combined with epinephrine.

This combination not only blocks nerve transmission in the area around the tumor, but also reduces intraoperative bleeding due to the vasoconstriction promoted by epinephrine, making it easier to visualize and remove the affected tissue (Bichakjian et al., 2016; Nestor et al., 2019).

The choice of local anesthesia has several advantages over sedation or general

anesthesia techniques. Firstly, it allows the patient to remain awake during the procedure, eliminating the risks associated with deep sedation or general anesthesia, such as respiratory or cardiovascular complications. This approach is especially important in MMS, which can involve multiple stages of excision and microscopic examination of tumor margins, extending the duration of the procedure without compromising patient safety or well-being (Aasi et al., 2014; Bader et al., 2020).

The use of local anesthesia facilitates intraoperative management, since the patient can be repositioned as needed, and the surgeon can obtain immediate responses in cases involving functional areas such as the eyelids or mouth. The local approach also minimizes postoperative recovery time, allowing the patient to quickly return to their daily activities, a significant benefit in terms of quality of life (Lang et al., 2021; Nestor et al., 2019).

Therefore, local anesthesia not only makes the procedure painless, but also plays a crucial role in the technical success and safety of Mohs Micrographic Surgery, making it a highly efficient choice for the management of non-melanoma skin cancer.

FIGURE 1 shows a schematic illustrating the stages of Mohs Micrographic Surgery (MMS), which is performed for the precise removal of skin tumors. The process is represented in four main stages: Identification and First Removal of Tumor Tissue

- The visible tumor is identified on the surface of the skin (epidermis and dermis).
- A thin layer of the affected tissue is initially removed, covering the visible tumor and a very small margin of apparently healthy tissue around it.

Examination of the removed tissue

- The first layer removed is analyzed microscopically to determine if there are any tumor cells in the margins.
- Based on the results, the anatomical map guides the exact location of the areas where the tumor persists.

Additional Removal

- If cancer cells are still detected, another thin layer of tissue is removed only in the areas where the tumor was found.
- This process is repeated selectively, layer by layer, reducing the excision of healthy tissue as much as possible.

Final Removal and Confirmation

- The procedure continues until the margins are completely free of tumor cells.

- The resulting wound is assessed, and reconstruction or closure is planned to preserve the function and aesthetics of the area.

FIGURE 1 highlights the precision and iterative nature of CMM, which combines progressive removal and microscopic analysis to ensure complete tumor removal while preserving as much healthy tissue as possible.

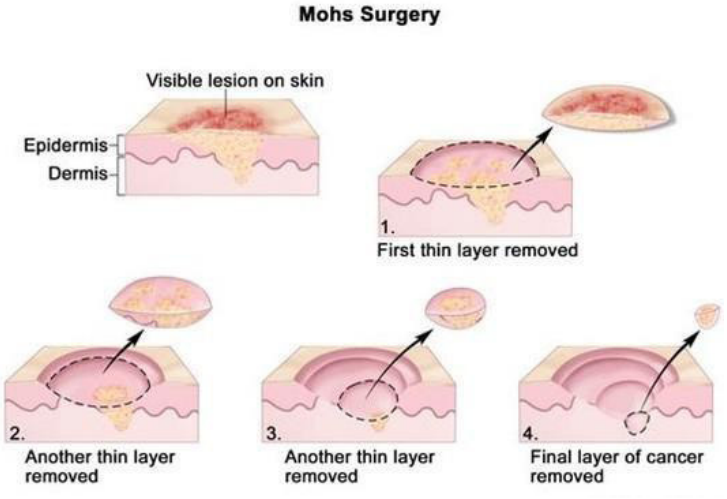

Figure 1: Descriptive stages of Mohs surgery procedures. Source: bhskin.com (2025).

First Removal of Tumor Tissue in Mohs Surgery

The first removal of tumor tissue in Mohs Micrographic Surgery (MMS) is a crucial step that combines surgical precision and detailed planning. The surgeon begins by removing the visible tumor along with a thin margin of apparently healthy tissue around it. This initial margin is deliberately small to preserve as much healthy tissue as possible, especially in critical anatomical areas such as the face and hands (Bichakjian et al., 2016; Bader et al., 2020). This initial process is based on the central philosophy of the Mohs technique: balancing complete tumor removal with functional and aesthetic preservation.

After the initial excision, the removed tissue is carefully marked with colored inks to map its anatomical orientation. This mapping allows the surgeon to accurately correlate the tumor's site of origin with the microscopic sections analyzed later. The use of different colors for different regions of the excised tissue is a standard practice that facilitates the identification of areas where tumor cells may still be present. This systematic process reduces the likelihood of errors and ensures accuracy in treatment

(Aasi et al., 2014; Nestor et al., 2019).

Anatomical mapping with colored inks plays an essential role in cases of recurrent tumors or those with poorly defined margins, where the extent of the tumor is not easily visible to the naked eye. By combining controlled excision with intraoperative microscopic analysis, CMM significantly increases cure rates, often reaching values higher than 99% for primary tumors (Jensen et al., 2018; Lang et al., 2021).

This approach also reduces the need for unnecessary excisions of healthy tissue, a fundamental advantage of the Mohs technique. Therefore, the first removal of tumor tissue, together with anatomical mapping, is one of the pillars of Mohs Micrographic Surgery, ensuring the effectiveness of the treatment and the least possible impact on the patient's tissue integrity.

Tissue Processing in Mohs Surgery

One of the most critical stages of Mohs Micrographic Surgery (MMS) is the processing of the removed tumor tissue. After excision, the tissue is immediately frozen using cryopreservation techniques, which allow for the rapid preparation of very thin sections. This approach is essential to preserve the three-dimensional architecture of the tumor and enable detailed analysis of the margins. The thin sections are obtained using specialized microtomes and then positioned on slides for microscopic examination. This process ensures that all tissue margins are assessed, which is not the case in traditional excision methods, where only a fraction of the margins are examined (Bichakjian et al., 2016; Aasi et al., 2014).

The samples obtained are stained with standard histological stains, such as hematoxylin and eosin, or specific techniques, depending on the type of tumor. These stains help differentiate tumor cells from healthy tissue. Simultaneously, a detailed map is created, correlating the analyzed sections to the corresponding anatomical site in the patient.

This mapping is crucial as it allows the surgeon to precisely identify the areas where the tumour persists, minimizing the unnecessary removal of healthy tissue and optimizing aesthetic and functional results (Bader et al., 2020; Lang et al., 2021).

Microscopic Examination in Mohs Surgery

The microscopic examination is carried out by the surgeon himself or by a specialized pathologist during the procedure. At this stage, the margins of the excised tissue are carefully analyzed to identify the presence of residual cancer cells. If tumor cells are detected, their exact location is determined based on the anatomical map previously created. This allows the surgeon to return to the exact location on the patient to remove only the necessary tissue, preserving the integrity of the surrounding healthy tissue (Jensen et al., 2018; Aasi et al., 2014).

The precision of this microscopic process is one of CMM's greatest advantages, resulting in extremely high cure rates of over 99% for primary tumors and 94% for recurrent tumors. This approach minimizes the likelihood of recurrence and significantly improves clinical outcomes compared to other excision methods (Bichakjian et al., 2016; Nestor et al., 2019). In addition, intraoperative microscopic examination eliminates the need for postoperative histopathological examinations, providing immediate results and optimizing treatment time.

Additional Tissue Removal

In Mohs Micrographic Surgery (MMS), when tumor cells are identified at the margins during intraoperative microscopic examination, the surgeon removes additional tissue only in the corresponding area, as indicated by the anatomical map created beforehand. This selective process ensures that only the necessary tissue is excised, preserving healthy tissue as much as possible, a unique feature of CMM. Additional removal and microscopic examination are repeated until all margins are free of tumor cells, which results in high cure rates, often exceeding 99% for primary tumors (Bichakjian et al., 2016; Aasi et al., 2014).

This iterative method not only maximizes therapeutic efficacy, but also reduces the need for additional procedures and the likelihood of tumor recurrence.

Wound closure

After confirming tumor cell-free margins, the surgeon decides how to proceed with wound closure, depending on the size, location and depth of the excision. Options include:

- **Direct closure**, which brings the edges closer to the skin and is ideal for small wounds or areas of greater elasticity.
- **Skin grafts**, which use skin from another region of the body to cover the defect, are an option in areas where direct closure is not feasible.
- **Skin flaps**, which reposition adjacent tissue to cover the wound, preserving function and aesthetics, particularly in areas such as the face and hands.
- **Healing by second intention**, where the wound is left to heal naturally, used in places of low tension or non-visible areas (Bader et al., 2020; Nestor et al., 2019).

Careful closure planning is essential to optimize functional and aesthetic results, especially in critical anatomical areas.

FIGURE 2 shows a schematic illustration of the wound healing process, comparing fine incisions and rounded or large wounds in three different stages:

Initial Internship (24 hours)

- **Fine incision**: Formation of a scab on the wound surface and activation of immune cells, which migrate to the site to start the repair process. The blood clot stabilizes the wound and prevents infection.
- **Rounded or wide wound**: The same process takes place, but the scab forms over a larger area. The immune cells begin to act on a wider and more challenging tissue.

Intermediate stage (3 to 7 days)

- **Fine incision**: Immune cells continue their repair work, promoting the formation of new blood vessels (angiogenesis) and the recruitment of repair cells. The wound begins to close.
- **Rounded or wide wound**: New vessel formation and cell recruitment take place in a larger, less organized space, requiring more time for significant progress in closure.

Final Stage (Weeks later)

- **Fine incision**: The newly repaired tissue is well formed, with the edges contracted and aligned, leading to efficient healing.
- **Rounded or wide wound**: Although the tissue is repaired, the area remains in contraction for longer due to the difficulty of bringing the edges together, which can result in less uniform or slower healing.

The figure highlights that fine incisions tend to heal more quickly and efficiently due to the smaller size of the area and closer proximity of the edges.

Rounded or wide wounds, on the other hand, present a greater challenge, leading to a longer and less uniform process.

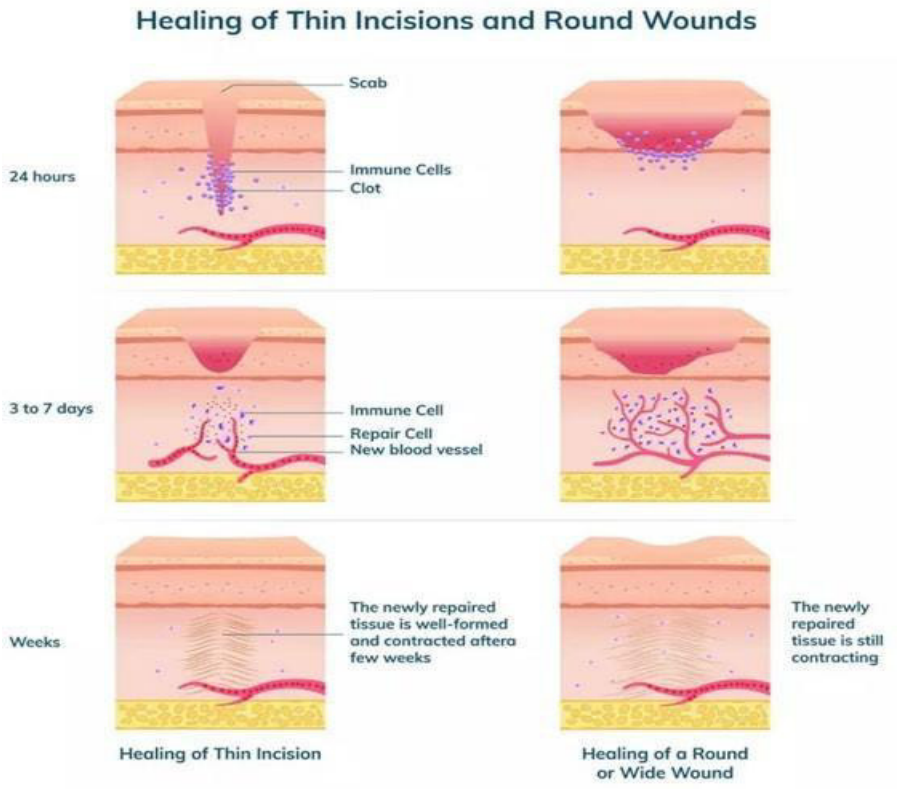

Figure 2: Descriptive stages of tissue regeneration after Mohs surgery. Source: bhskin.com (2025).

Post-operative care

Post-operative management is an essential component of MMC, contributing to successful healing and the prevention of complications.

The patient is given specific instructions to keep the area clean, change dressings regularly and use topical or oral medications, such as antibiotics or painkillers, as necessary. Preventing infection is a priority, and measures such as avoiding intense physical activity in the first few days are recommended. In addition, the patient is scheduled for follow-up appointments to monitor healing and check for signs of recurrence or complications (Lang et al., 2021; Bichakjian et al., 2016).

Long-term follow-up

Long-term follow-up is crucial for patients undergoing MMS, especially given the ongoing risk of new skin cancers. Regular consultations with the dermatologist are essential to detect any signs of recurrence or the development of new lesions early on. In addition, sun protection measures, such as the use of broad-spectrum sunscreen and protective clothing, are strongly recommended to reduce exposure to ultraviolet rays, one of the main risk factors for skin cancer (Jensen et al., 2018; Nestor et al., 2019).

Continuous vigilance and the adoption of preventive habits play a vital role in maintaining the patient's long-term health.

CONCLUSION

Mohs Micrographic Surgery (MMS) has proven to be the most effective and safest approach for treating non-melanoma skin cancer, especially in cases of high-risk, recurrent tumors or those located in critical anatomical areas. Its methodology, which combines precise excision and intraoperative microscopic analysis of the margins, provides high cure rates and maximum preservation of healthy tissue. The literature review showed that MMS is the gold standard for the management of basal cell and squamous cell carcinomas, with benefits both in terms of clinical outcomes and patient quality of life.

Despite its advantages, the technique faces challenges, such as the need for specialized infrastructure and highly trained professionals, which limits its availability in many health centers. Strengthening professional training and expanding access to MMS could contribute to a more equitable approach to skin cancer treatment. In addition, future research should explore new technologies and complementary approaches to further optimize the results obtained with MMS.

Mohs Micrographic Surgery thus represents a significant advance in the field of dermatologic oncology, reaffirming its indispensable role in current clinical practice.

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