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REVIEW

Mohs Micrographic Surgery and Improved Survival in Skin Cancer: A Narrative Review

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ABSTRACT

Mohs micrographic surgery (MMS) has been shown to achieve very low recurrence rates in skin cancer, and some studies suggest it may improve survival. We conducted a narrative review to assess the impact of MMS on the survival of patients with various skin cancer subtypes. Some retrospective studies suggest that MMS may enhance survival in patients with head and neck melanoma, lentigo maligna, lentigo maligna melanoma, invasive cutaneous squamous cell carcinoma (cSCC) (especially high-risk cSCC), and high-risk dermatofibrosarcoma protuberans, and, possibly, with certain malignant adnexal tumors as well. It is crucial to take these findings into account so as to appropriately prioritize patients and ensure accessibility of MMS. In both Merkel cell carcinoma and leiomyosarcoma, MMS has not consistently demonstrated improved survival compared with wide excision. Evidence regarding improved survival in extramammary Paget's disease remains limited.

Keywords: Mohs surgery; Survival; Melanoma; Lentigo maligna melanoma; Cutaneous squamous cell carcinoma; Merkel cell carcinoma

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Key Summary Points

Mohs micrographic surgery (MMS) achieves very low recurrence rates in skin cancer and may also improve survival in diverse skin malignancies.

This narrative review of the literature suggests that MMS versus wide local excision (WLE) may enhance survival in patients with head and neck melanoma, lentigo maligna, lentigo maligna melanoma, invasive cutaneous squamous cell carcinoma (especially high-risk cutaneous squamous cell carcinoma), and high-risk dermatofibrosarcoma protuberans, and possibly in malignant adnexal tumors.

In contrast, MMS has not consistently shown survival benefits over WLE in Merkel cell carcinoma, leiomyosarcoma, or extramammary Paget's disease, where evidence remains limited.

These findings should guide patient prioritization and resource allocation to improve accessibility and implementation of MMS in appropriate clinical settings.

Further prospective studies are needed to support current evidence and integrate survival outcomes of MMS into international guidelines.

INTRODUCTION

Currently, Europe is the region that has the highest number of ultraviolet (UV)-attributable cancer cases, with the highest number of melanoma cases worldwide and the second highest number of keratinocyte cancers [1]. The surgical goal in the treatment of cutaneous neoplasms is total tumor resection [2]. Mohs micrographic surgery (MMS) has been shown to have the highest cure rate and the lowest recurrence rate for diverse skin tumors, such as cutaneous squamous cell carcinoma (SCC) [3, 4], basal cell carcinoma (BCC) [5], cutaneous melanoma [6] and dermatofibrosarcoma protuberans (DFSP) [7], among others. MMS is the gold standard for the management of high-risk skin tumors, such as those located in anatomically complex areas or in patients where the maximum amount of tissue needs to be spared [8]. However, few studies have investigated the impact of MSC on the survival of patients with skin cancer, especially when compared with wide local excision (WLE) [9]. In recent years, a number of studies have suggested that MMS may increase survival in this setting [10, 11]. Here, we review the impact of MMS on the survival of patients with skin cancer compared with WLE.

MATERIALS AND METHODS

A narrative review of the literature was conducted. During February 2025, Medline and Google Scholar were searched in English and Spanish with the keywords "Mohs surgery," "survival," "disease specific survival," "overall survival," "squamous cell carcinoma," "cutaneous squamous cell carcinoma," "melanoma," "lentigo maligna," "lentigo maligna melanoma," "lentigo maligna melanoma," "basal cell carcinoma," "dermatofibrosarcoma protuberans," "Merkel cell carcinoma," "adnexal neoplasms," "extramammary Paget disease," "leiomyosarcoma," and "sebaceous carcinoma." Prospective and retrospective studies with ≥ 50 patients were included, as well as systematic reviews (SR) and meta-analyses (MA). Articles were screened according to their abstract and selected according to their relevance. The three authors (P.B.-S., M.M.-P., and D.M.-C.) performed the search, selection, and review of the articles.

Ethical Approval

This article is based on previously conducted studies and does not contain any new studies with human participants or animals performed by any of the authors. The procedures followed here were in accordance with the ethical standards of the committee responsible for human experimentation and with the 1975 Helsinki Declaration, revised in 1983. We have

Table 1 Studies analyzing the impact of Mohs surgery on melanoma survival

Type of melanoma	Authors and year	Sample size	Type of study, methodology	Inclusion criteria	Results
Unspecified cutaneous melanoma	Valentín-Nogueras et al. [12], 2016	2114	Single-center retrospective study Comparison of cutaneous MM cases treated with MMS between 2003 and 2012 with historical controls treated with WLE. Cases were classified into five subgroups according to their Breslow index	Histologically confirmed MMs, excluding those with equivocal diagnosis (e.g., dysplastic nevi with moderate or severe atypia) or desmoplastic MM	SDS was significantly higher in MMS-treated patients compared with historical controls in all subgroups except for tumors with a Breslow index between 2.50 and 3.99 mm
	Cheraghlou et al. [12], 2021	70,319	Multicenter, retrospective cohort analysis Comparison of stage I cutaneous MM cases treated with MMS or WLE from the NCD registry between 2004 and 2014	Primary MMs in patients with no other history of cancer, who were not metastatic, were not stage II or higher, and were not receiving adjuvant treatment	Modest increase in OS in patients treated with MMS versus those treated with WLE
	Elias et al. [13], 2019	132,726	Multicenter, retrospective cohort analysis Comparison of cutaneous MM cases treated with MMS or WLE from the NCD registry between 2004 and 2015	Histologically confirmed MMs, excluding MIS, LM and stage III or IV	No statistically significant differences were found between the two treatments with respect to OS at 5 years

Table 1 continued

Type of melanoma	Authors and year	Sample size	Type of study, methodology	Inclusion criteria	Results
Melanoma in situ	Taylor et al. [19], 2024	59,980	Multicenter, retrospective cohort analysis Comparison of cases of MIS treated with MMS or WLE from the SEER registry between 2000 and 2020	Histologically confirmed cutaneous MIS, excluding patients with invasive MM	Reduced risk of disease-specific mortality in the group of patients treated with MMS versus those treated with WLE on multivariate analysis
	Nosrati et al. [15], 2017	662	Retrospective analysis of a single-center prospective database Comparison of cases of MIS treated in a tertiary center with MMS or WLE between 1978 and 2013	Patients with histologically confirmed MIS, excluding those with invasive MM or multiple MM	No significant differences in recurrence rate, OS, or MM-specific survival were found between the two types of treatment
	Phan and Loya [14], 2019	28,637	Multicenter retrospective case study analysis Comparison of cases of MIS treated with MMS or WLE from the SEER registry between 2000 and 2020	Patients with histologically confirmed MIS	No statistically significant differences were found between the two treatment modalities with respect to OS and cancer-specific survival measured at 5, 10, and 15 years
	Phan et al. [16], 2020	7933	Multicenter retrospective case study analysis Comparison of head and neck MIS cases treated with MMS or WLE from the SEER registry between 1998 and 2015	Patients with histologically confirmed primary head and neck MIS, excluding those that occurred as secondary or late tumors	No significant differences were found in the percentages and rates of 5-year and 10-year cancer-specific survival and 5-year OS between the two treatment modalities
	Daniel et al. [17], 2021	33,983	Multicenter retrospective case study analysis Comparison of trunk or extremity MIS cases treated with MMS or WLE from the SEER registry between 2000 and 2015	Patients with histologically confirmed trunk or extremity MIS	No differences in 5-year local recurrence, melanoma-specific mortality and overall mortality were found between the two treatment modalities

Table 1 continued

LM lentigo maligna, *MIS* melanoma in situ, *MM* melanoma, *MMS* Mohs micrographic surgery, *NCD* National Cancer Database, *OS* overall survival, *DSS* disease-specific survival, *SEER* Surveillance, Epidemiology, and End Results, *WLE* wide lesion excision

not used patients' names, initials, or hospital numbers.

RESULTS

Melanoma

We found 20 articles (Tables 1, 2) evaluating the role of MMS in melanoma treatment and survival: 19 retrospective cohort studies [11–29] and 1 meta-analysis [30]. The most relevant findings are highlighted below.

In a study by Valentín-Nogueras et al. [12] that included 2114 melanomas in 1982 patients, mostly on the head and neck (53%), and 60% in situ, significantly longer disease-specific survival (DSS) at 5 years was found in those who received MMS, when compared with historical controls treated with WLE, especially those presenting with a Breslow index (BrI) below 2.50 mm and above 4 mm (98.8% vs 96% for BrI < 0.76; 77.4% versus 47% if BrI > 4). Similarly, in a study by Cheraghlou et al. [13] ($n = 70,319$), longer overall survival (OS) was found in patients treated with MMS versus WLE in all types of stage I cutaneous melanoma [hazard ratio (HR) of 0.86]. However, Elias et al. [14] in a large retrospective study ($n = 132,726$) found no significant difference in 5-year OS between the two procedures.

Specifically in relation to melanoma in situ (MIS), five studies [15–19] have evaluated survival after MMS. In the retrospective study by Phan and Loya [14] from 2019, with almost 30,000 cases of MIS treated by either MMS or WLE, OS at 5, 10, and 15 years was compared between the two groups and no significant differences were found. Similar results were reported in other retrospective studies, which also analyzed DSS [15–17]. However, very recently, Taylor et al. [19] published a large retrospective study ($n = 59,980$) comparing survival between WLE (32.9% of individuals with head and neck MIS) and MMS (74.6% of patients with head and neck MIS), in which multivariate analysis found a significant reduction in disease-specific mortality risk of about 39% in the MMS-treated group. These findings are probably related to the head

Table 2 Studies analyzing the impact of Mohs surgery on survival in patients with lentigo maligna and melanoma by body location

Type of melanoma	Authors and year	Sample size	Type of study, methodology	Inclusion criteria	Results
Melanoma of the head and neck	Hanson et al. [10], 2019	50,397	Retrospective case analysis Comparison of head and neck MM cases treated with MMS or WLE from the National Cancer Database between 2004 and 2015	MM of the head and neck in patients over 18 years of age at diagnosis, excluding those missing one or more of the covariates analyzed	Higher 5-year OS rates in those treated with MMS than in those treated with WLE. They also found OS benefits when adjusting for histological subtypes in SEM, LM, and LMM, but not in NM
	Taylor et al. [20], 2024	20,451	Retrospective case analysis Comparison of head and neck MM cases treated with MMS or WLE from the SEER registry between 2000 and 2020	Histologically confirmed invasive head and neck MM, excluding patients with distant disease	Higher rates of SDS at 5 and 10 years in those treated with MMS than in those treated with WLE. These differences are maintained in multivariate analysis adjusting for different confounding variables
	Chin-Lenn et al. [20], 2013	151	Retrospective case analysis Comparison of head and neck MM cases treated with MMS or WLE from the Alberta (Canada) cancer registry between 1997 and 2007	Histologically confirmed invasive MM of the head and neck, excluding MMs of the scalp, ear, neck, or mucosa, as well as those with positive margins	No differences were found for SDS at 5 years between the two groups
	Namin et al. [22], 2021	54,023	Retrospective case analysis Comparison of head and neck MM cases treated with NCD MMS or WLE between 2004 and 2016	Histologically confirmed invasive head and neck MM, excluding MIS and those MM not treated with MMS or WLE	No difference in OS was observed between the two treatments

Table 2 continued

Type of melanoma	Authors and year	Sample size	Type of study, methodology	Inclusion criteria	Results
Melanoma of the trunk and extremities	Burnett et al. [24], 2021	1416	Prospective single-center case study analysis Comparison of single-center MMS-treated trunk and extremity melanoma cases with historical controls treated with WLE between 1982 and 2017	MM of trunk or proximal portion of limbs	Significantly higher SDS was obtained in those cases with a Breslow index < 2 mm treated with MMS versus WLE, the difference being less significant with higher Breslow indices
	Demer et al. [23], 2021	188,862	Multicenter retrospective cohort study Comparison of trunk and extremity melanoma cases treated with MMS or WLE from the National Cancer Database between 2004 and 2015	MM of the trunk and extremities understood as involvement of the trunk, or upper or lower extremity; with known Breslow, intervened by MMS or WLE; and with known date of survival status	No differences in 5-year OS were associated between MMS and WLE treatment
	Bednar et al. [30], 2022	279,556	Meta-analysis with a fixed effects model from 4 studies collected from Medline, Embase, WoS, CENTRAL and EMCare comparing cases of trunk and extremity melanoma treated with either MMS or WLE	Studies comparing MMS with WLE in patients > 18 years, with survival or local recurrence outcomes. Comparisons with historical controls were excluded	OS, SDS, and local recurrence at 5 years were comparable between the group treated with MMS and those treated with WLE. MMS may identify exceptional cases requiring wider margins

Table 2 continued

Type of melanoma	Authors and year	Sample size	Type of study, methodology	Inclusion criteria	Results
Lentigo maligna	Taylor et al. [26], 2024	17,229	Multicenter, retrospective cohort analysis Comparison of LM cases treated with MMS or WLE from the SEER registry between 2000 and 2020	Histologically confirmed LM, excluding cases of LM Melanoma	Higher 5- and 10-year SDS rates in those treated with MMS than in those treated with WLE. These differences were maintained in multivariate analysis adjusting for different confounding variables, even in the case of MMS with tight margins (≤ 1 cm)
Lentigo maligna melanoma	Taylor et al. [27], 2024	5898	Multicenter, retrospective cohort analysis Comparison of cases of LMM treated with MMS or WLE from the SEER registry between 2000 and 2020	Histologically confirmed LM, excluding patients with distant disease and a diagnosis of LM	Higher 5- and 10-year SDS rates in those treated with MMS than in those treated with WLE regardless of Breslow index and surgical margin size
	Taylor et al. [28], 2024	514	Multicenter, retrospective cohort analysis Comparison of cases of LMM treated with MMS with narrow or wide margins from the SEER registry between 2000 and 2020	Histologically confirmed LMM, excluding patients with distant disease and a diagnosis of LM. Narrow margin was defined as < 1 cm or wide if > 1 cm	There were no statistically significant differences in SDS at 5 and 10 years between patients treated with narrow and wide margins

Table 2 continued

Type of melanoma	Authors and year	Sample size	Type of study, methodology	Inclusion criteria	Results
Lentigo maligna and lentigo maligna melanoma	Puyana et al. [29] 2024	22,852 (68% in situ, 56% facial)	Multicenter, retrospective cohort analysis Comparison of LM/LMM cases treated with MMS or WLE from the SEER registry between 2000 and 2019	Histologically confirmed LM/LMM that were intervened by MMS or WLE	A significant increase in OS was found in cases of LM in situ or with localized disease when using MMS. No significant differences in ESS were observed between the two treatments
Acral melanoma	Seo et al. [25], 2021	166	Single-center retrospective cohort study Comparison of AM cases treated with MMS or WLE at Severance Hospital in Seoul between 2005 and 2015	Patients with histologically confirmed AM and no evidence of metastatic disease at diagnosis or multiple melanomas	Kaplan–Meier analysis for OS and for RFS was statistically significant in favor of MMS over WLE. However, these differences did not hold up on multivariate analysis. The use of MMS was associated with a smaller postoperative defect after lesion excision than WLE

AM acral melanoma, *DFS* disease free survival, *LM* lentigo maligna, *LMM* Lentigo maligna melanoma, *MIS* melanoma in situ, *MM* melanoma, *MMS* Mohs micrographic surgery, *nm* nodular melanoma, *NCD* National Cancer Database, *OS* overall survival, *RFS* recurrence-free survival, *SDS* specific-disease survival, *SEER* Surveillance, Epidemiology, and End Results, *SEM* superficial extension melanoma, *WLE* wide lesion excision, *WoS* Web of Science

and neck location of the majority of MIS in the MMS group, as evidenced below.

Melanoma by Body Location and Lentigo Maligna

Melanoma of the Head and Neck Two studies [11, 20] have shown an increase in OS and DSS in patients treated with MMS. The first of these, published in 2019 by Hanson et al. [10], analyzed 50,397 cases of superficial spreading melanoma, lentigo maligna (LM), lentigo maligna melanoma (LMM) and nodular melanoma (NM). They found increased OS at 5 years for patients who underwent MMS [HR of 1.181], which was maintained after adjusting for histological subtypes, except for NM. Recently, a retrospective study by Taylor et al. [19] ($n=20,451$) showed that DSS was significantly higher in the MMS group than in the WLE group (92% at 5 years and 87% at 10 years versus 82% and 74%, respectively). The median BrI was 0.40 mm in the MMS group and 1.20 mm in the WLE group. Multivariate analysis revealed that patients treated with WLE had an increased risk of disease-specific death of about 49%. However, a study by Chin-Lenn et al. [20] ($n=151$) and another by Namin et al. [21] ($n=54,023$) found no significant differences in 5-year DSS in the former case and OS in the latter case between the two treatments.

Melanoma of the Trunk and Extremities A retrospective study by Demer et al. [22] ($n=188,862$), the largest study to date, found no difference in 5-year OS between the two treatment modalities. Similarly, a meta-analysis by Bednar et al. [23] from 2022 analyzing 279,556 cases from four studies (one retrospective cohort study and three database reviews) also showed no differences in OS, DSS, and local recurrence.

Acral Melanoma A retrospective cohort study [25] conducted in a South Korean hospital ($n=166$) found a 5-year OS rate of 88.8% in the MMS group versus 75.9% in the WLE group. However, these results did not hold up on multivariate analysis. MMS was associated with a smaller postoperative defect size.

Lentigo Maligna and Lentigo Maligna Melanoma Recently, Taylor et al. [26] conducted a retrospective multicenter study ($n=17,229$; 63.4% with LM on the head and neck) describing a higher 5- and 10-year DSS in cases treated with MMS (98% and 95%, respectively) than with WLE (97% and 91%, respectively). Multivariate analysis showed a reduction in disease-specific mortality of about 43% when using MMS. This superiority over WLE was maintained when MMS was performed with margins less than or equal to 1 cm. Regarding the invasive form of LM, Taylor et al., in another retrospective study with almost 6000 cases [27], reported an increase in DSS at 5 and 10 years with MMS (96% and 92%, respectively) versus WLE (92% and 85%, respectively) ($P<0.001$). These results were independent of BrI and surgical margin size. The same group performed another retrospective study in 2024 with 514 patients [28] to analyze the differences between performing MMS with a margin > 1 cm or < 1 cm at the LMM. They found no significant differences in terms of DSS. Another very recent retrospective study by Puyana et al. [29] involving 22,852 individuals with LM or LMM (68% in situ; 56% facial) showed a significant increase in OS in cases of LM in situ or with localized disease when using MSS. Patients with LM and MMS were 7% less likely to die of any cause than those undergoing WLE. Those with LM and localized disease who received MMS were 15% less likely to die from any cause. There was no difference in DSS between the two treatment groups.

Cutaneous Squamous Cell Carcinoma

In 2019, Xiong et al. [31] analyzed 366 intermediate-risk cutaneous SCCs (cSCC) (Brigham and Women's Hospital [BWH] stage T2a) and compared those treated with MMS or WLE in terms of disease progression (understood as overall recurrence or tumor-specific death) and found that it was significantly higher in those treated with EMA than in those treated with MMS (subdistribution HR of 2.9; 95% CI of 1.1–7.6: $P=0.03$). However, specific and overall cSCC mortality was not significantly associated with type of surgery.

Table 3 High-risk criteria for cutaneous squamous cell carcinoma

Brigham and Women's Hospital tumor classification [69]	AJCC tumor staging [70]
T0: in situ	TX: The primary tumor cannot be identified
T1: zero risk factors	Tis: in situ
T2a: one risk factor	T1: < 2 cm
T2b: two or three risk factors	T2: ≥ 2 cm and < 4 cm
T3: four risk factors/bone invasion	T3: ≥ 4 cm, minor bone erosion, perineural invasion or deep invasion
Risk factors: tumor diameter ≥ 2 cm, poorly differentiated histology, large caliber perineural invasion, and invasion beyond subcuticular fat	T4: cortical bone/marrow involvement (T4a), invasion of the skull or skull base (T4b)

AJCC American Joint Committee on Cancer

Recently, the riSCC model have been shown to outperform Brigham and Women's Hospital tumor classification and AJCC tumor staging in predicting poor outcomes in cSCC [35]. Additionally, the riSCC model incorporates variables such as age, immunosuppression status, lymphovascular invasion, location (head and neck versus trunk and extremities), and surgical treatment (Mohs surgery versus wide local excision), among others. For more information, visit: https://riscc.scoutconsortium.org

High-risk cSCC (hr-cSCC) (Table 3) accounts for 1–5% of all cSCC. In 2022, Soleymani et al. [32] conducted a retrospective study of 579 cases with hr-cSCC (either ≥ T3 according to the AJCC eighth edition staging system or as ≥ T2b according to the BWH staging system) treated with MMS alone, comparing the results with historical cohorts, mostly treated with WLE. They found a higher percentage of local recurrence-free survival at 10 years (96.9% in the MMS group versus 80–85% of historical controls), lower percentage of nodal involvement at 10 years (6.2% versus 15–3% of historical controls with WLE) and higher DSS at 5 years (95.7% versus 47–80% of historical controls) (Table 4). Importantly, patients who only underwent surgery were included. Those who received adjuvant radiotherapy, immunotherapy, or other advanced medical treatment were excluded, to be able to compare them adequately with historical controls. Another retrospective study including 145 h-cSCCs (BWH stage T2b-T3) treated with MMS found a similar disease-specific death (DSD) rate (4.8% during a median follow-up of 36 months) [33]. Also, Wang et al. conducted a single-center retrospective study comparing 216 patients with hr-cSCC (BWH stage T2b or T3) treated with either WLE or MMS [34]. Using a treatment-weighted inverse probability analysis, the 3-year cumulative incidence of all adverse outcomes was found to be higher among patients treated with WLE, including disease-specific death (17.5% in the WLE group versus 7.1% in the MMS group, with a weighted cause-specific HR of 2.74 [95% CI 1.54–4.88]; $P = 0.001$).

Recently, a retrospective multinational study including 23,166 localized SCCs aimed to develop a novel prognostic model (the "riSCC" model) [35]. The median follow-up was 27.4 months. The adjusted multivariable analysis showed that, compared with MMS, WLE had a DSD subdistribution HR of 2.0 (95% CI: 1.43, 2.78). A free downloadable application is available at https://riscc.scoutconsortium.org, and personalized risk assessments for DSD in cSCCs treated with MMS and WLE can be obtained.

Basal Cell Carcinoma

We did not find any studies comparing survival with MMS versus WLE for basal cell carcinoma.

Table 4 Studies analyzing the impact of Mohs surgery on survival in cutaneous squamous cell carcinoma

cSCC	Authors and year	Sampling size	Type of study, methodology	Inclusion criteria	Results
Medium-risk cSCC	Xiong et al. [31], 2020	366 (32.5% immunosuppressed)	Single-center retrospective cohort study Comparison of cases of SCC stage T2a (BWH stage system) with MMS or WLE between 2010 and 2012	Stage T2a SCC, excluding those treated with other therapies	Significantly more disease progression in those treated with WLE, than in those treated with MMS. However, specific and overall cSCC mortality was not significantly associated with type of surgery (WLE versus MMS)
High-risk cSCC	Marrazzo et al. [33], 2019	145	Single-center retrospective cohort study Analysis of high-risk cSCC cases treated with MMS alone at one center between 2011 and 2015	High-risk SCC (T2b or higher according to BWH stage system)	Patients treated with MMS showed disease specific death rate of 4.8% during a median follow-up of 36 months
	Soleymani et al. [32], 2022	579 (70% head and neck)	Retrospective multicenter cohort study Analysis of high-risk cSCC cases treated with MMS alone at two centers between 2000 and 2020	High-risk SCC (T3 or higher according to AJCC stage system or T2b or higher according to BWH stage system)	Lower rates of local recurrence, lymph node metastases and disease-related death than reported in historical controls
	Wang et al. [34], 2025	216	Single-center retrospective cohort study Comparison of high-stage SCC cases treated with MMS alone at one center between 2000 and 2019	High-stage SCC (T2b or T3 according to BWH stage system)	The 3-year cumulative incidence of all adverse outcomes was higher among WLE-treated patients, including disease-specific death

Table 4 continued

cSCC	Authors and year	Sampling size	Type of study, methodology	Inclusion criteria	Results
Invasive cSCC	Jambusaria-Pahlajani et al. [35], 2025	23,166	Retrospective multinational cohort study (12 centers) Analysis of cSCC cases between 1991 and 2023 including their treatments and outcomes, and development of a novel prognostic model ("riSCC")	cSCC cases were included, excluding cSCC in situ, basosquamous tumors and SCC of noncutaneous origin	The adjusted multivariable analysis showed that, compared with MMS, WLE had a DSD subdistribution HR of 2.0 (95% CI: 1.43, 2.78)

cSCC cutaneous squamous cell carcinoma, *AJCC* American Joint Committee on Cancer, *BWH* Brigham and Women's Hospital, *DSD* disease-specific death, *HR* hazard ratio, *MMS* Mohs micrographic surgery, *SCC* squamous cell carcinoma, *WLE* wide lesion excision

Dermatofibrosarcoma Protuberans

MMS has demonstrated a lower recurrence rate of DFSP than WLE [36], and recent studies have also reported longer survival (Table 5). A retrospective study from 2023 ($n=5313$) [37] described increased OS (HR 0.44) in the group of patients with DFSP treated with MMS. Very recently, Taylor et al. [38] in a retrospective study ($n=1772$) analyzing the North American Surveillance, Epidemiology, and End Results (SEER) registry found higher 5- and 10-year disease-free survival (DFS) rates in the MMS-treated group (100% and 99.5%, respectively) than in the WLE group (99% and 98%, respectively). Finally, a systematic literature review and meta-analysis published in 2024 [39] that included 136 studies found no difference in survival between MMS and WLE, except for recurrent DFSP (defined as recurrent tumors after prior treatment with curative intent), where they observed a disease-specific mortality of 1% with MMS versus 3.5% with WLE.

Merkel Cell Carcinoma

We found five articles [9, 40–42] related to Merkel cell carcinoma and survival with MMS, which all reflect inconclusive results (Table 6). We highlight the study by Cheraghlou et al. [9], which compared 2313 cases from the National CancerDatabase (NCD) and showed higher OS at 3, 5, and 10 years in the group treated with MMS compared with the group treated with WLE (87.4%, 84.5%, and 81.8% versus 86.1%, 76.9%, and 60.8%, respectively). Su et al. [41] analyzed 1185 cases from the NCD, finding that OS tends to be higher in those treated with MMS, but without statistical significance. Sharma et al. [42] compared 572 cases from the TriNetX registry and found no difference in OS at 1, 3, 5, and 10 years. Other studies reported similar findings [40, 43, 44], Furthermore, in 2022, Uitentuis et al. [45] conducted a systematic review including 31 studies (8506 patients), and concluded that there was no significant difference in survival and recurrence rates when comparing MMS and WLE.

Table 5 Studies analyzing the impact of Mohs surgery on survival in dermatofibrosarcoma protuberans

Authors and year	Sample size	Type of study, methodology	Inclusion criteria	Results
Xiong and Bordeaux [37], 2023	5	Multicenter retrospective cohort study Analysis of DFSP cases registered in the SEER registry between 2000 and 2020	Cutaneous or pigmented DFSP diagnosed between 200 and 2020, excluding those with unknown follow-up or time between diagnosis and treatment	In a multivariable Cox proportional hazards model, MMS treatment was associated with increased OS, while WLE with margins greater than or equal to 1 cm was not
Taylor et al. [38], 2024	1772	Multicenter, retrospective cohort analysis Comparison of DFSP cases treated with MMS or WLE from the SEER registry between 2000 and 2020	Histologically confirmed DFSP excluding patients with distant disease at diagnosis	Higher 5- and 10-year DFS rates in those treated with MSCs than in those treated with WLE. These differences are maintained on multivariate analysis adjusting for different confounding variables
Crum et al. [39], 2024	136 studies	Systematic literature review and meta-analysis Comparison of DFSP cases treated with MMS or WLE in the literature up to 2023	DFSP cases treated with MMS or WLE for which mortality data were available, including those treated with "Slow-Mohs." Articles with a single case and articles in languages other than English were excluded	No substantial differences in disease-specific mortality were observed between the MMS-treated and WLE-treated groups, except for recurrent DFSP

DFS disease-free survival, *DFSP* dermatofibrosarcoma protuberans, *MMS* Mohs micrographic surgery, *OS* overall survival, *SEER* Surveillance, Epidemiology, and End Results, *WLE* wide lesion excision

Table 6 Studies analyzing the impact of Mohs surgery on survival in Merkel cell carcinoma

Authors and year	Sample size	Type of study, methodology	Inclusion criteria	Results
Cheraghlou et al. [9], 2023	2313	Multicenter retrospective cohort study Comparison of stage T1/T2 MCC cases treated with MMS or WLE from the National Cancer Database between 2004 and 2019	Localized MCC stage T1/T2 with negative regional nodes and treated by surgery	Higher OS is demonstrated in those patients treated with MMS than in those treated with WLE at 3, 5, and 10 years. This result remained significant on multivariate survival analysis
Shaikh et al. [41], 2018	2610	Multicenter retrospective cohort study Comparison of MCC cases treated with MMS or WLE from SEER between 2004 and 2009	Not specified	No significant differences were found on multivariate analysis for OS and SDS between the two treatment modalities
Terushkin et al. [42], 2021	56	Single-center retrospective cohort study Comparison of stage I/II MCC cases treated with MMS at a US tertiary hospital between 2001 and 2019 with historical controls treated with WLE with or without RT	Stage I/II primary MCC treated with MMS monotherapy	They found no significant difference in survival between the two treatment modalities, although a direct comparison was not possible
Bloomstein and Eisen [37], 2022	57	Single-center retrospective cohort study Comparison of MCC cases treated with MMS or WLE at the University of California Davis Medical Center between 1994 and 2020	MCCs treated with either MMS or WLE at the University of California Davis Medical Center between 1994 and 2020	No significant differences were found between the two treatments with respect to OS and progression-free survival at 3 years

Table 6 continued

Authors and year	Sample size	Type of study, methodology	Inclusion criteria	Results
Utentius et al. [40], 2022	31 studies	Systematic literature review Comparison of MCC cases treated with MMS or WLE in the literature up to 2020	Studies with MCC cases treated with MMS or WLE that included at least five patients initially treated with surgery. Studies not published in English, French, German, Dutch, or Spanish were excluded. Also those cases in stage IV at diagnosis	No significant differences were found between the two treatment modalities in terms of survival or recurrence rates
Su et al. [38], 2023	1185	Multicenter retrospective case study analysis Comparison of stage I and II MCC cases treated with MMS or WLE from the NCD between 2004 and 2014, compared with the general US population and stratified by treatment	Stage I and II MCC without clinical evidence of nodal disease treated with MMS or WLE, excluding all other treatment modalities	Patients treated with MMS tend towards a higher OS and relative survival rate compared to those treated with WLE without reaching statistical significance. In addition, relative survival analysis demonstrates that stage I–II MCC is a component of the causes of mortality in the affected US population
Sharma and Demer [39], 2024	572	Multicenter retrospective case study Comparison of MCC cases treated with MMS or WLE from the TriNetX registry	MCCs matched for age, sex, race, stage, and adjuvant treatment	No significant differences were found between treatment with MMS or WLE with respect to OS at 1, 3, 5, and 10 years, as well as in surgical wound infection and postoperative bleeding

MCC Merkel cell carcinoma, *MMS* Mohs micrographic surgery, *NCD* National Cancer Database, *OS* overall survival, *RT* radiotherapy, *DSS* disease-specific survival, *SEER* Surveillance, Epidemiology, and End Results, *WLE* wide lesion excision

Cutaneous Leiomyosarcoma

Joshi et al. [46], in a recent multicenter retrospective cohort study of 382 cases collected from the SEER registry, found no significant difference in ESS between the MMS and the WLE groups (Table 7).

Dermal Pleomorphic Sarcoma

In 2023, Moore et al. [47] published a retrospective cohort study of 484 dermal pleomorphic sarcoma cases from the SEER registry in which they found no difference between OS and DSS when comparing MMS and WLE (Table 7).

Malignant Adnexal Tumors

Elias et al. [48] performed a survival analysis of patients with malignant adnexal tumors of the skin (MATS) from the NCD ($n=5676$). MMS showed similar OS to WLE. MMS was mostly used in porocarcinomas and microcystic adnexal carcinomas (Table 8).

Recently, Taylor et al. [49] examined 3963 cases extracted from the SEER registry (49.3% being sebaceous adenocarcinomas). MMS achieved a significantly higher mean DFS (231.7 months) compared with no surgery and also with WLE (mean 227.7 months). On multivariate analysis, only MMS had a disease-specific mortality risk reduction [adjusted HR 0.49, 95% 0.28–0.85, $P=0.011$]. In contrast, WLE did not show a benefit in DFS, even in the comparison with non-surgically treated cases. For sebaceous carcinoma specifically, two retrospective studies (181 and 2863 cases) [50, 51] found no difference compared with DSS, although MMS allowed greater preservation of healthy tissue.

Less Common Nonmelanoma Skin Cancers

Under this heading, Chen and Wang [8] grouped 6582 cases of differing malignancies, including Merkel cell carcinoma, MATS, fibromatous malignancies, and others. They compared the mortality of patients treated with MMS and WLE and found higher mortality in the WLE group, but the findings did not reach statistical significance.

Extramammary Paget's Disease

Bruce et al. [52] published a prospective series of patients with extramammary Paget's disease (EPD) ($n=87$) treated with MMS in 2022, compared with another retrospective series treated with WLE. They observed significantly higher 3-year DSS in the MMS group (93.3%) compared with the WLE group (65.9%).

DISCUSSION

We present herein a narrative review in which we have found several retrospective studies suggesting that, overall, MMS may increase survival in patients with various types of skin cancer, especially in individuals with head and neck melanoma [11, 20], LM [26], LMM [27], hr-cSCC [32], and DFSP [37, 38], and probably in various malignant adnexal tumors [49]. However, these studies have multiple limitations and need to be replicated. Since the ultimate goal of interventions in dermatological oncology is to increase the survival of patients with skin malignancies, it would probably be advisable to perform, and prioritize, MMS in patients with the tumors described above. In the articles reviewed concerning Merkel cell carcinoma, MMS has not consistently been shown to increase survival compared with WLE [9, 41, 45], nor in leiomyosarcoma [46] or acral melanoma [25]. Regarding EPD, studies are scarce, with a limited number of patients, and consequently do not allow conclusions to be drawn [52]. However, it should be remembered that MMS can allow preservation of healthy tissue and avoid very wide surgical margins (as recommended for Merkel cell carcinoma, leiomyosarcoma, and EPD), which is especially relevant in the head, neck, acral, and

Table 7 Studies analyzing the impact of Mohs surgery on survival in cutaneous leiomyosarcoma and dermal pleomorphic sarcoma

Cutaneous leiomyosarcoma	Joshi et al. [43], 2024	382	Multicenter retrospective case study analysis Comparison of cases of cLMS treated with MMS or WLE from the SEER registry between 2000 and 2021	Patients with cLMS; excluding patients with disseminated disease at diagnosis	No significant differences in SDS were found between MMS and WLE treatment. Multivariate analysis incorporating other variables also showed no differences
Dermal pleomorphic sarcoma	Moore et al. [44], 2023	484	Multicenter retrospective case study analysis Comparison of DPS cases treated with MMS or WLE from the SEER registry between 1976 and 2018	Patients with localized primary DPS, excluding noncutaneous and metastatic DPS	No statistically significant differences in OS and SDS were demonstrated between the two treatment modalities. The difference was also not significant when comparing MMS with excision without reported or known margins

cLMS cutaneous leiomyosarcoma, *DPS* dermal pleomorphic sarcoma, *MMS* Mohs micrographic surgery, *OS* overall survival, *DSS* disease-specific survival, *SEER* Surveillance, Epidemiology, and End Results, *SPD* dermal pleomorphic sarcoma, *WLE* wide lesion excision

Table 8 Studies analyzing the impact of Mohs surgery on survival in malignant adnexal tumors

Malignant adnexal skin tumors (MALT)	Taylor et al. [46], 2024	3963	Multicenter retrospective case study analysis Comparison of cases of MATS treated with MMS or WLE from the SEER registry between 2000 and 2020 using Kaplan–Meier curves and Cox regression models	Patients with histologically confirmed MATS* with a primary cutaneous origin	Only MMS showed an increase in disease-related survival compared to no surgery, while WLE did not improve it
	Elias et al. [45], 2023	5676	Multicenter retrospective case study Analysis of survival and demographic characteristics of MATS cases from the NCD between 2004 and 2017	Patients with MATS[a] included in the registry between 2004 and 2017	The use of MMS differed significantly according to tumor histology, geographic region and patient characteristics. MMS demonstrated similar OS to WLE, and is mainly used for porocarcinoma and adnexal microcystic carcinoma
Sebaceous adenocarcinoma	Phan and Loya [47], 2019	181	Multicenter retrospective case study Comparison of SA cases treated with MMS or WLE from the SEER registry between 1998 and 2015	Cases of primary SA limited to the eyelid region	Both OS and cancer-specific survival of MMS-treated patients did not differ from those treated with WLE at 5 and 10 years of follow-up
	Elias et al.[48], 2020	2863	Multicenter retrospective case study Comparison of SA cases treated with MMS or WLE from the NCD between 2004 and 2015	Histologically confirmed primary SA cases, excluding those with nodal extension, undergoing palliative treatment or stage III/IV	No significant differences were observed between the two treatment modalities in terms of 5-year OS, although MMS allowed for better margin control and preservation of healthy tissue

MATS malignant adnexal tumors of the skin, *MMS* Mohs micrographic surgery, *NCD* National Cancer Database, *OS* overall survival, *SA* sebaceous adenocarcinoma, *SEER* Surveillance, Epidemiology, and End Results

*Within the MATS, the following tumors were included: adenoid cystic carcinoma, cribriform carcinoma, tubular adenocarcinoma, apocrine adenocarcinoma, malignant nodular hidradenoma, malignant eccrine spiradenoma, sclerosing sweat duct carcinoma, papillary eccrine adenocarcinoma, malignant eccrine poroma, sebaceous adenocarcinoma, mucoepidermoid carcinoma, mucinous adenocarcinoma, mucin-producing adenocarcinoma, extramammary Paget's disease, malignant mixed tumor, pleomorphic adenoma carcinoma and malignant myoepithelioma

[a]MATS included: adnexal carcinoma NOS, sweat gland adenocarcinoma, apocrine adenocarcinoma, hidradenocarcinoma, malignant eccrine spiradenoma, adnexal microcystic carcinoma, digital papillary adenocarcinoma, porocarcinoma, sebaceous carcinoma, and eccrine adenocarcinoma

periorificial areas. Finally, we have not found any articles comparing survival of MMS versus WLE in basal cell carcinoma, probably given the overall good prognosis of this tumor.

Studies specifically assessing survival associated with MMS versus WLE in skin cancer are rather scarce and very recent (most date from the 2023–2024 biennium) and are generally not included in current guidelines such as those of the National Comprehensive Cancer Network [53–56] or the European Association of Dermato-Oncology (EADO) [57–60]. An exception is the treatment of MCC, where the EADO guidelines state that there is a similar rate of OS and DSS between MMS and WLE [61]. More studies, ideally prospective, are likely to be required for international guidelines to consider the potential survival benefit of MMS.

Despite the advantages of MMS, it requires a highly trained surgical and technical team, adequate equipment (for example, cryostat), and greater time, especially if several stages are performed [62, 63]. Furthermore, from an economic point of view, although MMS has proven to be highly cost-effective, initial costs may be higher [64]. MMS including paraffin-embedded tissue, also called slow Mohs, may be an alternative to consider, as it requires minimal training of the pathologist, pathology technician, and dermatological surgeon, and could be performed in almost any hospital [65, 66]. In addition, paraffin-embedded MSC may allow better analysis of infrequent tumors or those requiring immunohistochemical techniques [67].

Finally, noninvasive diagnostic techniques such as confocal microscopy and optical coherence tomography, among others, are gaining ground and being implemented in the preoperative setting to better define surgical margins and even evaluate tumor thickness. These techniques have the potential to reduce rates of incomplete excision, the number of surgical stages necessary in MMS, and local recurrence, as well as to minimize the need for invasive procedures [68]. Additionally, they may help in selecting patients with invasive tumors for further evaluation. In the long term, this approach could improve the survival rates of patients undergoing MMS or WLE, although current evidence remains limited.

LIMITATIONS

This review is limited by the fact that it is a narrative review and not a systematic review or meta-analysis. In addition, almost all the studies included are retrospective, and most of the studies are from the same group of authors (Taylor et al.), and use data from the SEER registry, which has important limitations. Also, a possible publication bias due to the fact that articles with a neutral result have not been published should be taken into account. These factors impede the generalizability of the findings and their conclusions, highlighting the need for prospective studies, ideally randomized, and with a prolonged follow-up period to detect differences in survival.

CONCLUSIONS

MMS not only presents lower local recurrence rates compared with WLE in the treatment of skin cancer but may also increase survival in patients with head and neck melanoma, LM, LMM, invasive cSCC, and high-risk DFSP, and probably in cases with diverse malignant adnexal tumors. It is essential to consider this to appropriately prioritize patients who would benefit from MMS, as well as to ensure its implementation in healthcare facilities to ensure its accessibility.

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Declarations

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REFERENCES

1. Brochez L, Volkmer B, Hoorens I, et al. Skin cancer in Europe today and challenges for tomorrow. J Eur Acad Dermatol Venereol JEADV. 2025;39:272–7.

2. Leus AJG, Frie M, Haisma MS, et al. Treatment of keratinocyte carcinoma in elderly patients—a review of the current literature. J Eur Acad Dermatol Venereol. 2020;34:1932–43.

3. van Lee CB, Roorda BM, Wakkee M, et al. Recurrence rates of cutaneous squamous cell carcinoma of the head and neck after Mohs micrographic surgery vs. standard excision: a retrospective cohort study. Br J Dermatol. 2019;181:338–43.

4. Rowe DE, Carroll RJ, Day CL. Prognostic factors for local recurrence, metastasis, and survival rates in squamous cell carcinoma of the skin, ear, and lip. Implications for treatment modality selection. J Am Acad Dermatol. 1992;26:976–90.

5. Work Group, Invited Reviewers, Kim JYS, et al. Guidelines of care for the management of basal cell carcinoma. J Am Acad Dermatol. 2018;78:540–59.

6. O'Hern K, Crum OM, Demer AM, Brewer JD. Intraoperative immunohistochemistry during Mohs micrographic surgery and staged excision decreases local recurrence rates for invasive cutaneous melanoma: a systematic review and meta-analysis. Dermatol Surg Off Publ Am Soc Dermatol Surg Al. 2024;50:601–10.

7. Sanabria A, Pinillos P, Chiesa-Estomba C, et al. Comparing Mohs micrographic surgery and wide local excision in the management of head and neck dermatofibrosarcoma protuberans: a scoping review. J Dermatol Treat. 2024;35:2295816.

8. Tolkachjov SN, Brodland DG, Coldiron BM, et al. Understanding Mohs micrographic surgery: a review and practical guide for the nondermatologist. Mayo Clin Proc. 2017;92:1261–71.

9. Chen M, Yunqiong WY. Survival outcomes of Mohs surgery versus wide local excision for less common nonmelanoma skin cancers: a stabilized inverse probability of treatment weighting analysis. Dermatol Basel Switz. 2023;239:877–88.

10. Cheraghlou S, Doudican NA, Criscito MC, et al. Overall survival after Mohs surgery for early-stage Merkel cell carcinoma. JAMA Dermatol. 2023;159:1068–75.

11. Hanson J, Demer A, Liszewski W, et al. Improved overall survival of melanoma of the head and neck treated with Mohs micrographic surgery versus wide local excision. J Am Acad Dermatol. 2020;82:149–55.

12. Valentín-Nogueras SM, Brodland DG, Zitelli JA, et al. Mohs micrographic surgery using MART-1 immunostain in the treatment of invasive melanoma and melanoma in situ. Dermatol Surg. 2016;42:733.

13. Cheraghlou S, Christensen SR, Agogo GO, Girardi M. Comparison of survival after Mohs micrographic surgery vs wide margin excision for

early-stage invasive melanoma. JAMA Dermatol. 2019;155:1252–9.

14. Elias ML, Lambert WC. Surgical management of localized melanoma: a national cancer database retrospective review. Br J Dermatol. 2019;181:832–3.

15. Phan K, Loya A. Mohs micrographic surgery versus wide local excision for melanoma in situ: analysis of a nationwide database. Int J Dermatol. 2019;58:697–702.

16. Nosrati A, Berliner JG, Goel S, et al. Outcomes of melanoma in situ treated with Mohs micrographic surgery compared with wide local excision. JAMA Dermatol. 2017;153:436–41.

17. Phan K, Onggo J, Loya A. Mohs micrographic surgery versus wide local excision for head and neck melanoma-in-situ. J Dermatol Treat. 2020;31:559–62.

18. Daniel VT, Crawford A, Kiefe CI, Mahmoud BH. Recurrence and mortality of melanoma in situ of the trunk or extremities: a surveillance, epidemiology, and end results analysis. Dermatol Surg. 2021;47:1.

19. Taylor MA, Sharma D, Thomas S, et al. Reduced disease-specific mortality in melanoma in situ patients treated with Mohs surgery over wide local excision: a study of the surveillance, epidemiology, and end results database. J Am Acad Dermatol. 2024. https://doi.org/10.1016/j.jaad.2024.11.021.

20. Taylor MA, Sharma D, Thomas S, et al. Improved disease-specific survival in head and neck cutaneous melanomas treated with Mohs surgery over wide local excision in the United States. J Am Acad Dermatol 2024;91(6):1256–58.

21. Chin-Lenn L, Murynka T, McKinnon JG, Arlette JP. Comparison of outcomes for malignant melanoma of the face treated using Mohs micrographic surgery and wide local excision. Dermatol Surg. 2013;39:1637–45.

22. Namin AW, Oudin EM, Tassone PT, et al. Treatment of cutaneous melanoma of the head and neck with wide local excision versus Mohs. Laryngoscope. 2021;131:2490–6.

23. Demer AM, Hanson JL, Maher IA, Liszewski W. Association of Mohs micrographic surgery vs wide local excision with overall survival outcomes for patients with melanoma of the trunk and extremities. JAMA Dermatol. 2021;157:84–9.

24. Burnett ME, Brodland DG, Zitelli JA. Long-term outcomes of Mohs micrographic surgery for invasive melanoma of the trunk and proximal portion of the extremities. J Am Acad Dermatol. 2021;84:661–8.

25. Seo J, Oh Y, Kim SK, et al. Slow Mohs micrographic surgery for acral melanoma treatment in Korean patients. Dermatol Surg. 2021;47:e42–6.

26. Taylor MA, Thomas SI, Sharma D, et al. Improved disease-specific survival in lentigo maligna treated with Mohs surgery over wide local excision: a retrospective cohort analysis. Br J Dermatol. 2024;190:350–2.

27. Taylor MA, Thomas SI, Fernandez JM, et al. Enhanced disease-specific survival in lentigo maligna melanoma patients treated with Mohs surgery over wide local excision: a retrospective cohort analysis of the Surveillance, Epidemiology, and End Results database. J Am Acad Dermatol. 2024;91:939–41.

28. Taylor MA, Thomas SI, Sharma D, Voss VB. No disease-specific survival benefit with wide margin Mohs surgery for lentigo maligna melanoma. Dermatol Surg. 2024. https://doi.org/10.1097/DSS.0000000000004341.

29. Puyana C, Ilyas M, Weiss E, Saleeby E. Mohs micrographic surgery for the treatment of lentigo maligna and lentigo maligna melanoma: an outcomes study. J Drugs Dermatol JDD. 2024;23:1094–9.

30. Bednar ED, Zon M, Abu-Hilal M. Morbidity and mortality of melanoma on the trunk and extremities treated with Mohs surgery versus wide excision: a systematic review. Dermatol Surg. 2022;48:1–6.

31. Xiong DD, Beal BT, Varra V, et al. Outcomes in intermediate-risk squamous cell carcinomas treated with Mohs micrographic surgery compared with wide local excision. J Am Acad Dermatol. 2020;82:1195–204.

32. Soleymani T, Brodland DG, Arzeno J, et al. Clinical outcomes of high-risk cutaneous squamous cell carcinomas treated with Mohs surgery alone: an analysis of local recurrence, regional nodal metastases, progression-free survival, and disease-specific death. J Am Acad Dermatol. 2023;88:109–17.

33. Marrazzo G, Zitelli JA, Brodland D. Clinical outcomes in high-risk squamous cell carcinoma patients treated with Mohs micrographic surgery alone. J Am Acad Dermatol. 2019;80:633–8.

34. Wang DM, Vestita M, Murad FG, et al. Mohs surgery vs wide local excision in primary high-stage cutaneous squamous cell carcinoma. JAMA Dermatol 2025:e246214.

35. Jambusaria-Pahlajani A, Jeanselme V, Wang DM, et al. riSCC: A personalized risk model for the development of poor outcomes in cutaneous squamous cell carcinoma. J Am Acad Dermatol. 2025. https://doi.org/10.1016/j.jaad.2025.02.076.

36. Martin ECS, Vyas KS, Batbold S, et al. Dermatofibrosarcoma protuberans recurrence after wide local excision versus Mohs micrographic surgery: a systematic review and meta-analysis. Dermatol Surg. 2022;48:479–85.

37. Xiong DD, Bordeaux JS. Incidence and survival outcomes of dermatofibrosarcoma protuberans from 2000 to 2020: a population-based retrospective cohort analysis. Dermatol Surg. 2023;49:1096–103.

38. Taylor MA, Thomas SI, Beach L, et al. Enhanced disease-specific survival in patients with dermatofibrosarcoma protuberans treated with Mohs surgery in the United States. Dermatol Surg. 2024. https://doi.org/10.1097/DSS.0000000000004350.

39. Crum OM, O'Hern K, Demer AM, Brewer JD. Disease-specific mortality of dermatofibrosarcoma protuberans after Mohs surgery versus wide local excision: a systematic review and meta-analysis. Dermatol Surg. 2024;50:317–21.

40. Bloomstein JD, Eisen DB. Merkel cell carcinoma treatment with Mohs micrographic surgery versus wide local excision: a retrospective cohort survival analysis. J Am Acad Dermatol. 2022;87:1115–7.

41. Su C, Bai HX, Christensen S. Relative survival analysis in patients with stage I–II Merkel cell carcinoma treated with Mohs micrographic surgery or wide local excision. J Am Acad Dermatol. 2023;88:e131–2.

42. Sharma AN, Arora J, Baum CL, Demer AM. Equivalent overall survival for microcystic adnexal carcinoma after Mohs micrographic surgery and wide local excision: a population-based analysis. Dermatol Surg Off Publ Am Soc Dermatol Surg Al. 2024. https://doi.org/10.1097/DSS.0000000000004298.

43. Shaikh WR, Sobanko JF, Etzkorn JR, et al. Utilization patterns and survival outcomes after wide local excision or Mohs micrographic surgery for Merkel cell carcinoma in the United States, 2004–2009. J Am Acad Dermatol. 2018;78:175-177.e3.

44. Terushkin V, Brodland DG, Sharon DJ, Zitelli JA. Mohs surgery for early-stage Merkel cell carcinoma (MCC) achieves local control better than wide local excision ± radiation therapy with no increase in MCC-specific death. Int J Dermatol. 2021;60:1010–2.

45. Uitentuis SE, Bambach C, Elshot YS, et al. Merkel cell carcinoma, the impact of clinical excision margins and Mohs micrographic surgery on recurrence and survival: a systematic review. Dermatol Surg. 2022;48:387–94.

46. Joshi TP, Zhang SY, Shimizu I. Equivalent disease-specific survival after Mohs micrographic surgery versus wide local excision for cutaneous leiomyosarcoma: a surveillance, epidemiology, and end results program-based analysis. J Am Acad Dermatol. 2024;92(1):172–3.

47. Moore KJ, Schmults CD, Ruiz ES. No difference in survival for primary cutaneous pleomorphic sarcoma after Mohs surgery and wide local excision. J Am Acad Dermatol. 2023;88:495–8.

48. Elias ML, Yan BY, Koptyev J, et al. Surgical management of adnexal carcinomas with Mohs micrographic surgery and wide excision: a survival analysis. Int J Dermatol. 2023;62:e253–5.

49. Taylor MA, Swedek M, Halloran P, et al. Enhanced disease-specific survival among individuals with malignant adnexal tumors of the skin treated with Mohs surgery: a national database study. Dermatol Surg. 2024. https://doi.org/10.1097/DSS.0000000000004397.

50. Phan K, Loya A. Mohs micrographic surgery versus wide local excision for sebaceous adenocarcinoma of the eyelid: analysis of a national database. J Plast Reconstr Aesthetic Surg JPRAS. 2019;72:1007–11.

51. Elias ML, Skula SR, Behbahani S, et al. Localized sebaceous carcinoma treatment: wide local excision verses Mohs micrographic surgery. Dermatol Ther. 2020;33: e13991.

52. Bruce KH, Kilts TP, Lohman ME, et al. Mohs surgery for female genital Paget's disease: a prospective observational trial. Am J Obstet Gynecol. 2023;229:660.e1-660.e8.

53. Schmults CD, Blitzblau, Rachel, Aasi SZ, Alam M. NCCN clinical practice guidelines in oncology (NCCN Guidelines®) Merkel cell carcinoma version 1.2024. NCCN; 2023.

54. Bourdeaux J, Blitzblau R, Aasi SZ, et al. NCCN clinical practice guidelines in oncology (NCCN Guidelines®) dermatofibrosarcoma protuberans version 1.2025. NCCN; 2024.

55. Bourdeaux J, Blitzblau R, Aasi SZ, et al. NCCN clinical practice guidelines in oncology (NCCN Guidelines®) Basal Cell SKIN CANCER VERSION 3.2024. NCCN; 2024.

56. Schmults CD, Blitzblau R, Aasi SZ, Alam M. NCCN clinical practice guidelines in oncology (NCCN Guidelines®) squamous cell skin cancer version 1.2024. NCCN; 2023.

57. Saiag P, Grob J-J, Lebbe C, et al. Diagnosis and treatment of dermatofibrosarcoma protuberans. European consensus-based interdisciplinary guideline. Eur J Cancer. 2015;51:2604–8.

58. Peris K, Fargnoli MC, Kaufmann R, et al. European consensus-based interdisciplinary guideline for diagnosis and treatment of basal cell carcinoma—update 2023. Eur J Cancer. 2023. https://doi.org/10.1016/j.ejca.2023.113254.

59. Stratigos AJ, Garbe C, Dessinioti C, et al. European consensus-based interdisciplinary guideline for invasive cutaneous squamous cell carcinoma: Part 2. Treatment-update 2023. Eur J Cancer Oxf Engl. 2023;193:113252.

60. Garbe C, Amaral T, Peris K, et al. European consensus-based interdisciplinary guideline for melanoma. Part 2: treatment—update 2024. Eur J Cancer. 2025. https://doi.org/10.1016/j.ejca.2024.115153.

61. Gauci M-L, Aristei C, Becker JC, et al. Diagnosis and treatment of Merkel cell carcinoma: European consensus-based interdisciplinary guideline—update 2022. Eur J Cancer. 2022;171:203–31.

62. Bouzari N, Olbricht S. Histologic pitfalls in the Mohs technique. Dermatol Clin. 2011;29:261–72.

63. Ceilley RI, Del Rosso JQ. Current modalities and new advances in the treatment of basal cell carcinoma. Int J Dermatol. 2006;45:489–98.

64. Ravitskiy L, Brodland DG, Zitelli JA. Cost analysis: Mohs micrographic surgery. Dermatol Surg. 2012;38:585–94.

65. Löser CR, Rompel R, Möhrle M, et al. S1 guideline: microscopically controlled surgery (MCS). JDDG J Dtsch Dermatol Ges. 2015;13:942–51.

66. Mansilla-Polo M, Morgado-Carrasco D, Toll A. Review on the role of paraffin-embedded margin-controlled Mohs micrographic surgery to treat skin tumors. Actas Dermosifiliogr. 2024;115:555–71.

67. Ebede TL, Lee EH, Dusza SW, et al. Clinical value of paraffin sections in association with Mohs micrographic surgery for nonmelanoma skin cancers. Dermatol Surg. 2012;38:1631.

68. Venturi F, Pellacani G, Farnetani F, et al. Noninvasive diagnostic techniques in the preoperative setting of Mohs micrographic surgery: a review of the literature. Dermatol Ther. 2022;35: e15832.

69. Work Group, Invited Reviewers, Kim JYS, et al. Guidelines of care for the management of cutaneous squamous cell carcinoma. J Am Acad Dermatol. 2018;78:560–78.

70. Amin MB, Edge S, Greene F, et al. editors. AJCC cancer staging manual. 8th ed. New York: Springer; 2017.