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ORIGINAL ARTICLE

Surgeon Experience Level and Number of Mohs Stages: A Prospective Observational Study of In-training Surgeons

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ABSTRACT

Background: Comparisons of Mohs surgeons by experience level (early-, mid-, late-career) and their respective number of stages taken during Mohs have not detected any difference. However, data comparing the number of stages for attending Mohs surgeons to Mohs fellows is non-existent. The objective of this study was to prospectively observe and compare the mean number of Mohs stages taken for attending Mohs surgeons and fellows.

Methods: Procedural data from 2,140 Mohs cases over 24 months was collected and divided into an attending or fellow surgeon cohort.

Results: The attending cohort had a higher mean number of stages for all non-melanoma skin cancer when compared to the fellow cohort ($p=0.005$). The attending cohort demonstrated a higher mean number of stages for non-aggressive, non-superficial basal cell carcinoma ($p<0.001$), but no difference was found for other cancer subtypes. No difference was detected when comparing the two cohorts' performance at high, medium, and low risk surgical areas.

Conclusion: The attending cohort had a higher mean number of stages overall for combined types of skin cancer and for non-aggressive, non-superficial basal cell carcinoma specifically when stratified by diagnosis as compared to the fellow cohort. No difference existed in the mean number of stages between the cohorts based on surgical area.

INTRODUCTION

Mohs micrographic surgery (MMS) is a surgical technique utilized for the treatment of specific cutaneous malignancies. By utilizing intraoperative microscopic margin examination of frozen-section histology specimens, the tumor burden is examined in stages. This stage-based approach allows for more complete margin control and improved

tissue preservation - promoting a high cure rate, and improving patient satisfaction.^{1,2}

As numerous stages may be required to achieve margin clearance, the number of stages is an objective measure of MMS outcomes. Factors influencing the number of stages can be oversimplified into two broad categories: tumor-specific and surgeon-specific factors.^{3,4,5} Tumor specific factors include challenging anatomical sites with

minimal tissue laxity, such as the nasal tip, eyebrow, eyelid, ears. Additionally, tumor histopathology, such as aggressive or superficial variants of nonmelanoma skin cancer, which can make preoperative clinical determination of tumor extent difficult, or perineural invasion, and/or deep invasion.⁶ Intraoperative margin size decision for each stage and pre-excision curettage/debulking exemplify surgeon-specific factors.^{3,6} Although previously hypothesized to be an important factor, the number of stages performed has not been shown to be influenced by MMS surgeon experience level (Table 1).^{5,6}

This study aimed to expand on the previously examined influence of surgeon experience level on the number of stages performed during MMS by prospectively investigating Mohs fellows in-training compared to attending Mohs surgeons. The lower experience level of fellows was hypothesized to result in a higher mean number of stages required during MMS as compared to the higher experience level and hypothesized lower mean number of stages for attending-level surgeons. If accurate, this would demonstrate a higher efficiency for more experienced surgeons in extirpating tumors compared to less experienced surgeons – arguing against previous findings of no significant difference in mean number of stages for different experience levels.

METHODS

Data was prospectively collected over a 24-month time period from a private and academic clinic. One attending surgeon maintaining active membership with the American College of Mohs Surgery (ACMS) and two fellows of an Accreditation Council for Graduate Medical Education (ACGME)-accredited MMS fellowship formed the data

pool. The database collected the experience level cohort, numbers of stages required, diagnosis, and surgical site for 2,140 cases.

For the primary objective, surgeons were divided into two cohorts (attending or fellow) based on experience level during each MMS procedure. For the secondary objective, diagnoses were confirmed with pathology reporting and intraoperative microscopic examination. In an effort to provide cohesive statistical validity with previous studies evaluating the impact of experience level in MMS outcomes, only basal cell carcinomas (BCCs) and squamous cell carcinomas (SCCs) were included in data analysis as they represent the majority of tumors encountered in MMS practice.⁶ BCCs were categorized as superficial, aggressive (infiltrative, micronodular, morpheaform), and non-aggressive (nodular, mixed superficial and nodular). Similarly, SCCs were categorized as superficial (in situ/Bowen's), aggressive (spindled/moderately-poorly differentiated), and non-aggressive (well-differentiated/keratoacanthoma-type). If two diagnoses existed within the same tumor, categorization was based on the more aggressive diagnosis. Surgical sites were subclassified into high (H), medium (M), and low (L) risk areas according to the 2012 appropriate use criteria (AUC) for MMS.⁷

Descriptive statistics on the number of stages of each experience level cohort were analyzed using a computer software program (R version 4.0.3 Statistical Software [2020]; The R Foundation, Vienna, Austria). Independent samples t-tests were conducted to compare the mean number of stages between the two experience level cohorts for overall number of stages, number of stages by specific diagnosis, and number of stages by surgical site (defined

Table 1. Previous Literature on the Impact of Experience Level on Mohs Outcomes

Reference	Definitions of Experience Level Cohorts	Mean Number of Stages *	Key Findings
Steinman et al.⁴	<ul style="list-style-type: none"> In-residency Only MMS Training Post-Residency Courses Only Post-Residency Courses & Observational Preceptorship 	1.66	Mean number of stages for non-fellowship trained surgeons compared favorably to previously published reports.
Alhaddad et al.⁵	<ul style="list-style-type: none"> Early (less than five years in practice) Mid (five-to-ten years in practice) Advanced (greater than ten years in practice) 	1.88	No significant difference was observed between years in practice and number of stages per case.
Alam et al.⁶	<ul style="list-style-type: none"> Early- (less than five years in practice) Mid-career (greater than five years in practice) 	1.93 (Early) 1.70 (Mid)	Mohs surgeons removed tumors with similar mean numbers of stages regardless of experience level

* Mean number of stages overall for all variants of BCC and SCC.

above). Statistical significance was defined as $p < 0.05$

RESULTS

The mean number of stages for all MMS outcomes regardless of experience level cohort was 1.90, with 99.0% of tumors being removed in four or fewer stages. This data is comparable to previously published data examining experience level influence on MMS outcomes (Table 1).^{5,6} Independent samples t-tests for mean stages between experience level cohorts for all types of skin cancer is revealed in Figure 1. The fellow cohort reported a lower mean number of stages as compared to the attending cohort (1.8 vs. 1.94, respectively; $p=0.005$).

When the difference in mean number of stages between experience level cohorts was

stratified by skin cancer diagnoses (Table 2), the fellow cohort demonstrated a lower mean number of stages for non-superficial, non-aggressive BCC in

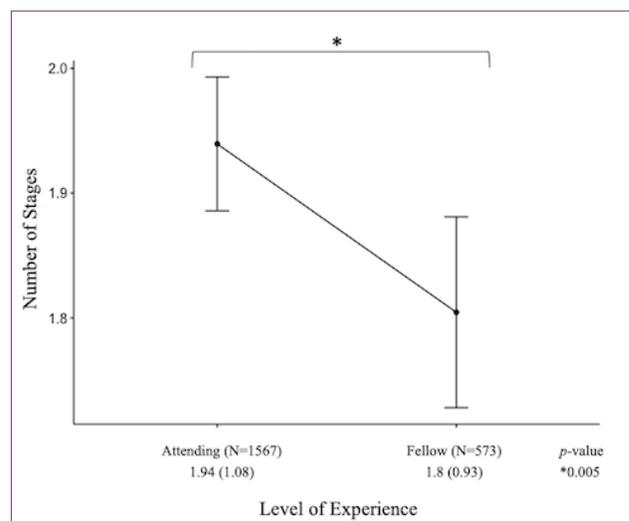


Figure 1. Mean Number of Stages by Experience Level Cohorts for All Types of Skin Cancer

comparison to the attending cohort (1.88 vs. 1.65, respectively; $p < 0.001$). No significant differences existed between cohorts in the other specific skin cancer diagnoses.

Analysis of surgical site separated into areas H, M, and L revealed no difference in the mean number of stages for the two experience level cohorts. Within areas H, M, and L, the fellow cohort had a lower mean number of stages, but this failed to reach statistical significance compared to the attending cohort ($p = 0.088$, $p = 0.067$, $p = 0.762$, respectively).

DISCUSSION

Previous comparison of attending MMS surgeons failed to detect differences in the mean number of stages for early-, mid-, and late-career surgeons (Table 1).^{5,6} Early- (less than five years in practice) and mid-career (greater than five years in practice) Mohs surgeons removed tumors with similar mean numbers of stages.⁶ Further differentiation into early- (less than five years in practice), mid- (five-to-ten years in practice), and advanced (greater than ten years in practice), showed no significant relationship between years in practice and mean number of stages.⁵ This study is a novel examination of the influence of in-training experience level on MMS stage count.

The lower mean number of stages for the less experienced fellow cohort argues against the authors' hypothesis that the in-training cohort would have a higher mean number of stages. Two factors may have influenced these results. The higher mean number of stages for the attending cohort may reflect the increased complexity of cases performed by the attending cohort compared to the fellow cohort. At the training sites in this study, the attending cohort was more likely to be the

primary surgeon for the most complex cases (aggressive histology, larger tumor size, challenging anatomical presentations) to promote the best MMS outcomes which may create discordance between cohorts. Separately, the authors felt the less experienced fellow cohort may take larger initial margins compared to the maximal tissue sparing, smaller margin efforts of the attending cohort. This may result in the fellow cohort incidentally extirpating the tumor in a smaller number of stages (contributing to a lower mean number of stages when compared to the attending cohort) with the trade-off of less normal tissue preservation.

When outcomes were broken down by specific skin cancer diagnosis, a lower mean number of stages existed for the fellow cohort when compared to the attending cohort for all types of skin cancer individually, but reached significance only for non-aggressive, non-superficial BCC diagnoses. The authors believe non-aggressive, non-superficial BCC diagnoses reached significance because of the high sample size amongst both cohorts within this diagnosis. Therefore, non-aggressive, non-superficial BCC reflected the data pool most accurately. Superficial and aggressive variants of BCC and SCC were secondarily hypothesized to contribute to a higher number of stages for the fellow cohort compared to the attending cohort because of the potential for larger subclinical margins complicating removal. Similar to the reasoning behind the overall lower mean number of stages for the fellow cohort, the inverse demonstration of a lower mean number of stages for the fellow cohort when treating superficial and aggressive variants of BCC and SCC was felt to also result from larger initial margins and inadvertent tumor clearance (despite possible larger subclinical margins).

In the 2012 determination of AUC for MMS, numerous factors were incorporated to

Table 2. Independent Samples *t*-test Results for Number of Stages Between Training Groups by Specific Skin Cancer Diagnosis

Diagnosis	Attending	Fellow	<i>p</i> -value
aBCC	<i>N</i> = 376	<i>N</i> = 147	
	2.36 (1.27)	2.23 (1.14)	0.245
aSCC	<i>N</i> = 49	<i>N</i> = 22	
	2.29 (1.51)	2 (1.2)	0.397
BCC	<i>N</i> = 729	<i>N</i> = 262	
	1.88 (1.01)	1.65 (0.76)	< 0.001
sBCC	<i>N</i> = 30	<i>N</i> = 14	
	1.9 (1.06)	1.79 (0.8)	0.695
SCC	<i>N</i> = 317	<i>N</i> = 95	
	1.5 (0.67)	1.46 (0.62)	0.602
sSCC	<i>N</i> = 42	<i>N</i> = 18	
	1.9 (0.88)	1.5 (0.71)	0.067

aBCC (aggressive basal cell carcinoma - infiltrative, micronodular, morpheiform), *aSCC* (aggressive squamous cell carcinoma - spindled/moderately to poorly differentiated), *BCC* (non-aggressive basal cell carcinoma), *sBCC* (superficial basal cell carcinoma), *SCC* (non-aggressive squamous cell carcinoma - well-differentiated/keratoacanthoma-type), *sSCC* (superficial squamous cell carcinoma - in situ/Bowen's)

provide uniform appropriate use recommendations, including body locations grouped based on risk: areas H (high), M (medium), and L (low).⁷ Areas of minimal

tissue laxity and high cosmetic sensitivity (i.e. areas H and M) may require a greater number of stages because of the attempt to preserve normal tissue with smaller intraoperative margin choice.⁶ The authors hypothesized this may translate to a higher mean number of stages for the less experienced fellow cohort compared to the attending cohort.

In analysis of the data, while not statistically significant, the fellow cohort demonstrated a lower mean number of stages when compared to the attending cohort for all three areas. Previously discussed factors (case distribution, larger initial margin choice) influencing the lower mean number of stages overall for the less experienced fellow cohort may have also contributed to the unexpected results for mean number of stages when separated by anatomical location. The possibility of attentive supervision from the attending Mohs surgeon during fellow-performed high-risk cases in areas with high technical and aesthetic concerns impacting this result cannot be ruled out.

Sampling bias was a limitation of this study. Attending and fellow surgeons were analyzed from a single practice and fellowship program, rendering this sample an incomplete representation of all MMS clinics and MMS fellowships. While the ACGME accreditation system unifies fellowship training requirements, considerable variation exists between fellowships in terms of teaching methods for surgical care. Additionally, because this study was restricted to one geographical region (Midwestern United States) it does not reflect the patient population that may be encountered outside of this study. Numerous MMS clinics and fellowship programs exist in various parts of the United States, altering the patient population (age, severity of malignancy, overall health state,

socioeconomic status) and tumor burden that fellows or attendings will encounter at outside programs not assessed in this study.⁶ Therefore, the results of this study may not reflect all in-training MMS experiences and outcomes.

It is important to recognize the fellows were under training and supervised by the same attending. Because of this exposure, fellows may follow a similar technical approach as the attending. As such, training bias is another limitation of this study. This implies these results may not be generalizable to all fellows performing MMS, as fellows at other programs are instructed by different attendings who may have different technical approaches and views of training.

CONCLUSION

No uniform recommendations for number of stages in MMS exists. Benefits and drawbacks exist for both higher and lower stage counts. Improved retention of normal tissue, structure, and function may result from higher stage counts; however, an increased operative time and resource utilization may be seen. In contrast, a smaller number of stages portends to reduced operative times and resource utilization but may cause increased loss of normal tissue.⁶ The authors' hypothesis of the less experienced fellow cohort demonstrating a higher mean number of stages was disproven as the fellow cohort had a lower mean number of stages compared to the attending cohort. However, this finding does support prior studies, which have failed to find a higher mean number of stages associated with lower experience levels (Table 1). Overall, the attending cohort had 0.14 more stages on average compared to fellow cohort, which was unlikely to make a significant impact on clinical outcomes. The

authors believe an obvious experience gap exists between attending surgeons as compared to in-training fellows. The perceived experience gap was not portrayed in analysis of mean number of stages during MMS. Factors such as unequal complex case distribution and larger initial margin choice/inadvertent tumor clearance may influence demonstration of this experience gap in regard to mean number of stages. Therefore, mean number of stages may not be the best objective measure of experience level. Alternatively, when utilizing stage count to evaluate the differences between experience levels of MMS surgeons, a higher number of stages may reflect an advanced, tissue-sparing skill level. Further studies are warranted to examine the impact of in-training surgeons on MMS outcomes.

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