Original article

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Prevalence of wound complications following Mohs micrographic surgery (MMS): a cross-sectional study of 1000 patients undergoing MMS and wound repair in a UK teaching hospital

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Abstract

Background. Mohs micrographic surgery (MMS) for nonmelanoma skin cancer is often quoted as having an excellent safety profile.

Aim. To determine the complication rate of patients undergoing MMS in a large UK Mohs unit and subdivide complication rates into mild/intermediate and major, and to identify potential risk factors necessitating a clinical intervention.

Methods. This was a single-centre, cross-sectional study of 1000 consecutive cases of MMS performed with in-house repair. Notes from the postsurgical dressing clinics were reviewed at Visit 1 (Days 7–14) and Visit 2 (approximately Week 6). Based upon the intervention required and effect on cosmetic/functional outcome, complications were classified as minor, intermediate or major. Logistic regression modelling was used to identify risk factors associated with a complication that needed a clinical intervention (i.e. intermediate or major).

Results. In total, 1000 Mohs surgeries were performed on 803 patients, resulting in 1067 excisions. Complication rates in our cohort were low (minor 3.6%, intermediate 3.1% and major 0.8%) Potential risk factors for developing a complication included skin graft (unadjusted OR = 4.89, 95% CI 1.93–12.39; fully adjusted OR = 7.13, 95% CI 2.26–22.45) and patients undergoing surgery on the forehead (unadjusted OR = 3.32, 95% CI 0.95–11.58; fully adjusted OR = 5.34, 95% CI 1.40–20.42). Patients whose wounds were allowed to heal by secondary intention healing (6.8%) exhibited no complications.

Conclusion. We advocate that patients should be informed during the consent procedure that less than 1 in every 100 patients (0.75%) undergoing MMS will have a serious adverse event (major complication) affecting their cosmetic or functional outcome.

Background

Nonmelanoma skin cancer, the commonest cancer in the UK, has increased in incidence by 56% over the past decade, with the majority of these being basal cell carcinomas (BCCs).[1] Mohs micrographic surgery (MMS) is widely regarded as the gold standard surgical treatment for high risk or recurrent BCCs on the face or neck. MMS uses intraoperative histological examination of all tissue margins using frozen sections to ensure complete tumour excision, and is characterized by higher cure rates than traditional wide local excision alone. Critically MMS enables maximal preservation of surrounding healthy tissue, often leading to superior functional and cosmetic outcomes.[2,3]

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MMS is widely considered to have an excellent safety profile, with postoperative complication rates reported in the literature of 0.7%–6%.[4–9] The majority of studies have been conducted in the USA and have been incorporated into Supplementary Table S1. Inherent differences in both population demographics and healthcare provision make it difficult to translate findings from studies using existing healthcare data from one country to another. To date, the largest UK cohort ($n = 565$) of patients undergoing MMS has been prospectively collected in the UK Mohs Acceptance and Patient Safety (MAPS) collaboration study.[5] In addition to other variables, postoperative complications were reviewed and grouped into major or minor; however, specific complication rates were not provided. Thus, it is important to establish a descriptive analysis of complication rates in a UK context, which would be useful to enable fully informed consent from patients. Furthermore, identification of specific risk factors predisposing to such complications would enable a more personalized approach to be taken with each patient prior to undergoing surgery.

The main objective of this study was to perform a descriptive analysis of postoperative complication rates in patients undergoing MMS in a single UK teaching hospital. A secondary objective was to identify any risk factors that resulted in a complication necessitating a clinical intervention.

Methods

Study design

This was a single-centre cross-sectional study of 1000 consecutive cases of MMS meeting our inclusion criteria. Patients were collected from Salford Hospital, a tertiary dermatology centre in the Northern Care Alliance National Health Service (NHS) Foundation Trust, covering the Greater Manchester region in the northwest of the UK, which is staffed by four UK Mohs surgeons. A retrospective review of patients' electronic records was performed and anonymized data were extracted from those who attended the department from October 2018 to February 2020. The inclusion criteria included: (i) use of MMS to treat ≥ 1 BCC; (ii) repair of the surgical defect in-house by a Mohs surgeon; and (iii) attendance of the patient in-house postoperative suture removal and wound assessment. Exclusion criteria included repair of the postoperative surgical defect by another specialty or if the patient did not attend for the in-house postoperative suture removal and wound assessment.

Data collection

Patient data were retained on a secure encrypted database, and included patient demographics and intraoperative details. Standard clinical protocols for patients undergoing MMS at our centre include two postoperative visits: (i) Visit 1 for either suture removal 5–7 days postoperatively for primary repair/flaps and grafts, or surgical wound review at 14 days for secondary intentional healing; and (ii) Visit 2 for postsurgical review (for all repair types). Graft harvesting in the unit included the use of bolsters. Postoperative antibiotics are not routinely given in the unit, but can be given at the discretion of the operating surgeon (5.6% of cases) (Table 1). Specific adverse postoperative outcomes were recorded, based on the clinical entries made at either Visit 1 or Visit 2, and were divided into three categories: minor (defined as no intervention required and no effect on the cosmetic/functional outcome); intermediate (defined as intervention required but no effect on the cosmetic/functional outcome); and major (defined as intervention required and likely to adversely affect the cosmetic/functional outcome) (Fig. 1).

Statistical analysis

Descriptive analysis of the patient population was performed for patient demographics and intraoperative variables by each treated lesion. Continuous data were presented as mean ± SD or median and interquartile range, depending on the distribution of the data. Categorical variables were presented by counts and proportion in percentages.

Four important risk factors were clinically identified: (i) type of repair, (ii) anatomical site, (iii) anticoagulant use and (iv) the number of MMS layers taken during the procedure. Various potential confounders and mediators were identified for the relationship between each risk factor and postsurgical complication. A sequential analysis approach was performed, and three logistic regression models were fitted, with the risk factor as the main exposure and the presence of postsurgical intermediate or major complication as the outcome. The three models used were: (i) univariable logistic regression model; (ii) multivariable logistic regression model adjusted for potential confounders; and (iii) multivariable logistic regression with adjustment for both potential confounders and mediators. The effect estimates were presented as OR with corresponding 95% CI. Clustering by individual patients, in cases where multiple BCCs were treated in the same

Table 1 Demographics associated with each lesion treated with Mohs micrographic surgery, divided into lesions with and without complications.

Parameter	Lesions not requiring an intervention (*N* = 1026)	Lesions requiring an intervention (*N* = 41)
Age, years; median (IQR)	72.0 (62.0–78.0)	71.0 (59.0–76.0)
Sex, *n* (%)		
Male	588 (57.3)	22 (53.7)
Female	438 (42.7)	19 (46.3)
BCCs excised per case, *n* (%)		
1	888 (86.5)	37 (90.2)
2	129 (12.6)	4 (9.8)
3	9 (0.9)	0 (0.0)
Lesion location		
Nose	306 (29.8)	21 (51.2)
Cheek	189 (18.4)	4 (9.8)
Forehead	128 (12.5)	9 (22.0)
Scalp	70 (6.8)	2 (4.9)
Ear	70 (6.8)	1 (2.4)
Eye	70 (6.8)	1 (2.4)
Lip	53 (5.2)	1 (2.4)
Eyebrow	52 (5.1)	0 (0.0)
Temple	45 (4.4)	1 (2.4)
Chin	20 (1.9)	1 (2.4)
Jaw	12 (1.2)	0 (0.0)
Neck	11 (1.1)	0 (0.0)
Mohs layers taken, *n* (%)		
1	636 (62.0)	21 (51.2)
2	325 (31.7)	17 (41.5)
3	56 (5.5)	2 (4.9)
4	6 (0.6)	1 (2.4)
5	2 (0.2)	0 (0.0)
6	1 (0.1)	0 (0.0)
Method of defect repair, *n* (%)		
Primary	409 (39.9)	11 (26.8)
Secondary	70 (6.8)	0 (0.0)
Flap	471 (45.9)	20 (48.8)
Graft	76 (7.4)	10 (24.4)
Prophylactic antibiotics, *n* (%)		
None	898 (87.5)	34 (82.9)
Systemic	53 (5.2)	7 (17.1)
Topical	75 (7.3)	0 (0.0)
Medical history, *n* (%)		
Hypertension	237 (23.1)	8 (19.5)
Cardiovascular conditions	143 (13.9)	8 (19.5)
Diabetes	48 (4.7)	2 (4.9)
Previous history of cancer[a]	45 (4.4)	4 (9.8)
Immunosuppression	23 (2.2)	0 (0.0)
Implanted device[b]	6 (0.6)	0 (0.0)
Type of anticoagulation, *n* (%)		
None	796 (77.6)	32 (78.0)
Antiplatelet	160 (15.6)	4 (9.8)
Coumarin	40 (3.9)	1 (2.4)
NOAC	30 (2.9)	4 (9.8)

BCC, basal cell cancer; IQR, interquartile range; NMSC, non-melanoma skin cancer; NOAC, novel oral anticoagulant. [a]Excluding NMSC; [b]pacemaker or implantable cardioverter–defibrillator *in situ*.

patient on the same day or on different days, was performed using the patient's hospital number. A complete case analysis approach was used, and any missing data were retrieved by reviewing the primary data source. Variables with substantial missing data were not included. All analysis was performed in the statistical program Stata (V16.1; StataCorp, College Station, TX, USA).

Results

Surgeries

In total, 1321 MMS day cases were reviewed, of which 1000 underwent in-house repair. In these 1000 cases, 1067 individual BCCs were excised from 803 patients. Of the 1000 cases, 86.5% (n = 865) had a single BCC removed per case, 12.6% (n = 126) had 2 BCCs excised per case and 0.9% (n = 9) had 3 BCCs excised per case. Of the 803 patients, 78.3% (n = 620) underwent a single day-case MMS procedure, while 19.3% (n = 155), 2% (n = 16) and 0.4% (n = 3) respectively underwent 2, 3 and 4 separate MMS day-case procedures. As expected for patients undergoing MMS, most patients were elderly, with a median age of 72 years (interquartile range 59–78) years, and male predominance (n = 460, 57.3%). Excision was most commonly performed on the nose (n = 327, 30.1%) and was most commonly repaired using a flap (n = 491, 46.0%). Table 1 shows the baseline characteristics of this group and includes patient variables (age, sex, medical history and current medications), tumour variables (anatomical location) and intraoperative variables (number of layers taken, method of repair).

Complication rates

Minor, intermediate and major complication rates occurred in 3.6% (n = 38), 3.1% (n = 33) and 0.8%

Minor complications *(No intervention required and no effect on the cosmetic/functional outcome)*	**Intermediate complications** *(Intervention required but no effect on the cosmetic/functional outcome)*	**Major complications** *(Intervention required and likely to adversely affect the cosmetic/functional outcome)*
1. **Minor bleed at home no medical intervention required**	1. Crusting requiring debridement	1. Major wound dehiscence (requiring surgical intervention with a cosmetic complication)
2. **Minor haematoma no medical intervention required**	2. Major bleed requiring further treatment	2. Complete graft necrosis requiring debridement which healed well
3. **Partial flap/graft necrosis no debridement**	3. Haematoma requiring treatment (antibiotics)	
4. **Minor slough not no medical intervention required**	4. Postoperative infection requiring oral antibiotics	
5. **Minor wound dehiscence no medical intervention required**	5. Partial flap/graft necrosis requiring debridement which healed well	
6. **Minor crusting requiring topical treatment (emollient/mupirocin)**		

Figure 1 Subclassification criteria for complications, grouped into minor, intermediate or major based on whether a clinical intervention was required and whether there was any cosmetic or functional impairment.

(n = 8) of cases, respectively (Table 2). No significant differences were noted between the individual surgeons. Given that a medical intervention was required for both intermediate and major complications (n = 41; 3.8%), these groups were subsequently grouped together for both descriptive analysis and logistic regression analysis, as they were considered to be a clinically relevant cohort requiring a medical intervention.

Risk factors

Out of the four previously identified risk factors for postsurgical complications (see Statistical analysis section above), we found that the method of repair and the location of defect were associated with an increase in the likelihood of having a complication that needed an intervention. Patients undergoing a graft had a seven-fold increase in the odds of developing a clinically relevant complication compared with patients undergoing primary closure (unadjusted OR = 4.89, 95% CI 1.93–12.39; fully adjusted OR = 7.13, 95% CI 2.26–22.45) (Supplementary Table S2). Patients undergoing surgery on the forehead had increased odds of developing a complication (unadjusted OR = 3.32, 95% CI 0.95–11.58; fully adjusted OR = 5.34, 95% CI 1.40–20.42) (Supplementary Table S3). Patients undergoing surgery on the nose had significantly increased odds of developing a complication compared with those undergoing surgery on the cheek according to the unadjusted models (unadjusted OR 3.24, 95% CI 1.09–9.68) but the effect estimate was attenuated in the fully adjusted model (OR = 2.65, 95% CI 0.89–7.91), suggesting that the increased risk of complications in this anatomical region is due to the repair method required for closure and/or the number of layers that are taken (Supplementary Table S3). No complications were reported in those patients in whom their wound was allowed to heal by secondary intention healing (SIH) (n = 70; 6.8%).

Regarding the third factor of anticoagulants, the use of antiplatelet medication and coumarins were not associated with an increased risk of developing a complication, whereas the use of novel oral anticoagulants

Table 2 Prevalence of complications per Mohs case (n = 1000).

Complication type	*n* (%)
Minor	
Minor bleed at home no medical intervention required	2 (0.19)
Minor haematoma no medical intervention required	4 (0.37)
Partial flap/graft necrosis no debridement	6 (0.56)
Minor slough, no medical intervention required	7 (0.66)
Minor wound dehiscence no medical intervention required	9 (0.84)
Minor crusting requiring topical treatment (emollient/mupirocin)	10 (0.94)
Intermediate	
Major bleed requiring further treatment	1 (0.09)
Haematoma requiring treatment (antibiotics)	1 (0.09)
Crusting requiring debridement	4 (0.37)
Partial flap/graft necrosis requiring debridement, which healed well	9 (0.84)
Postoperative infection requiring oral antibiotics	18 (1.69)
Major	
Major wound dehiscence (requiring surgical intervention with a cosmetic complication)	1 (0.09)
Complete graft necrosis requiring debridement, which healed well	7 (0.66)

Complications were subclassified and grouped into three categories: minor (defined as no intervention required and no effect on the cosmetic/functional outcome); intermediate (defined as intervention required but no effect on the cosmetic/functional outcome); and major (defined as intervention required and likely to adversely affect the cosmetic/functional outcome).

was significantly associated with an increased risk of complications only in the unadjusted model (OR = 3.32, 95% CI 1.01–10.85) but not in the fully adjusted model (OR = 1.99, 95% CI 0.51–7.77) (Supplementary Table S4).

The fourth risk factor, the number of MMS layers taken, was not significantly associated with any increased risk of complications in either the unadjusted or fully adjusted models (unadjusted OR = 1.30, 95% CI 0.87–1.92; fully adjusted OR = 1.35, 95% CI 0.88–2.07) (Supplementary Table S5).

Discussion

To our knowledge, this is the largest study to describe the postoperative complication rates following MMS in a UK centre. Because of the protocols used within our unit, specifically in regards to routine postoperative follow-up visits, thorough characterization of the incidence and the subtype of complication was possible. We found that 3.6% and 3.1% of patients developed a minor or intermediate complication, respectively; these were defined as such because of the negligible effect that they had in adversely affecting the long-term functional or cosmetic outcome. Although they should not be completely dismissed, these complications should be framed in the correct context, i.e. that many of these complications, particularly within the minor group, could be considered on the spectrum of normal wound healing and are easily manageable. These rates are compatible with previous studies reported in the literature (Supplementary Table S1). Furthermore, it was also reassuring that no adverse events (AEs) were recorded in patients whose wounds were allowed to heal by SIH (Supplementary Table S2), supporting several studies that have shown that SIH can provide excellent cosmetic results.[10,11] Although SIH is not suitable for every wound defect, generally being reserved for concave anatomical locations,[12] these results should encourage general dermatologists performing skin surgery that SIH should not be overlooked for wound reconstruction.

Personalized medicine/surgery refers to the process of predicting, preventing and treating a patient based on that individual's specific needs rather than on a population average.[13] Given that MMS has such high cure rates, the application of personalized healthcare within the MMS arena is suited to predicting postoperative complications that require clinical management, thereby allowing postoperative reviews to be tailored to an individual. In our study, patients who developed an intermediate or major complication required a clinical intervention, suggesting that this cohort of patients may require greater postoperative monitoring.

Despite this being a single-centre retrospective study, we were able to create a robust database containing multiple data points per patient/lesion, and thus we were able to perform an analysis that not only took account of clustering by patient but also ascertained the risk of complication per BCC. After adjusting for confounders and mediators, we found that there was an increased risk of developing a complication necessitating a clinical intervention if the patient received a graft or if they had surgery on the forehead. An increased risk of performing surgery on the nose was also seen after adjusting for confounders but not mediators, suggesting that the increased risk of developing a complication in this location was more likely due to the type of repair being performed rather than to the anatomical location. However, the increased risk of complications seen for MMS performed on the forehead persisted after adjusting for repair method; the reason for this is unclear.

Although our study included a large number of patients, the incidence of AEs was extremely small.

Furthermore, there were low event numbers and sparse data for certain anatomical locations. This resulted in wide confidence intervals in our linear regression modelling and it was not possible to precisely estimate the effect of these risk factors. Additionally, there is currently no consensus criteria to assess MMS complications, leading us to develop our own criteria (minor/intermediate/major) based upon the final clinical result, in terms of cosmetic or functional outcome. Given the wide variability of classifications used within the literature, it would be prudent to confirm the relevance of these criteria by first using a Delphi method study that included patient participation, to come to a consensus regarding relevant MMS AEs. This could then be followed up through a prospective multicentre, multinational MMS case registry with the aim of developing a robust model/calculator to predict an individual's risk of developing a complication. Such a model could be used preoperatively or intraoperatively when planning a repair technique.

Conclusion

In this study, we have confirmed that local anaesthetic day-case MMS for BCC on the head and neck has a very good safety profile. We would advocate that patients should be informed during the consent process that 'less than one in every hundred patients (0.75%) undergoing MMS will have a serious adverse event affecting their cosmetic or functional outcome'.

What's already known about this topic?

- MMS is characterized by high cure rates, minimal sacrifice of healthy tissue and an excellent safety profile.
- Large UK studies determining the rate of AEs are limited.

What does this study add?

- This is the largest review of MMS and associated complications in the UK.
- We found that the incidence of AEs with the potential to affect the cosmetic or functional outcome negatively is extremely low, at <1%.

Conflict of interest

The authors declare that they have no conflict of interest.

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Not applicable.

Ethics statement

Ethics approval was granted by the NHS local research ethics committees (IRAS 295578). Informed consent was not applicable.

Data availability

Data are available on request from the corresponding author.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. Overview of studies examining complication rates in patients undergoing Mohs micrographic surgery.
Table S2. Logistic regression modelling to determine whether there were any particular types of repair associated with a complication requiring an intervention.
Table S3. Results from the multivariable logistic regression models to identify whether any particular surgical site was associated with a complication requiring an intervention.
Table S4. Logistic regression analysis was used to identify whether the use of an anticoagulant was associated with a complication requiring an intervention.
Table S5. Logistic regression analysis was used to identify whether the number of Mohs layers taken during surgery was associated with a complication requiring an intervention.

