Analysis of Mohs Micrographic Surgery Over 5 Years in Single Institution Center

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Background: Mohs micrographic surgery (MMS) is a unique minimal marginal surgery that offers cure rates superior to other treatments of skin cancers. Our purpose was to report our experience with MMS for treatment of skin cancers, the clinical characteristics, and recurrence rates of the skin cancers, and MMS operation times. Methods: We retrospectively evaluated 293 patients who were diagnosed with skin cancer and treated by MMS and several reconstructive methods from May 2010 to April 2015. Results: The male-female patient ratio was 0.47:1, and mean patient age was 70.88 years (male, 69.98 years; female, 72.2 years). The most frequent age group was the seventh decade (36%). The most common cancer was basal cell carcinoma (57.3%), followed by squamous cell carcinoma (42.7%). The most commonly involved site was the face (80.8%), particularly the nose. Local flap was the most common method of repairing surgical defects (79.8%), followed by primary closure (13%). Recurrence after MMS was observed in 3 of 293 patients (1.0%). The minimum and maximum MMS operative times were 65 and 251 minutes, and the mean operative time was 131 minutes. The mean operative time per stage was 46.7, 43.6, and 40.0 minutes for the first, second, and third, respectively. Image studies for cancer metastasis revealed lymph node enlargement in 6 patients. Conclusion: MMS is a reliable and satisfactory method for treatment of skin cancer, and offers a low recurrence rate.

Key Words: Mohs micrographic surgery, Recurrence rate, Operation time

INTRODUCTION

As a result of the global phenomenon of an increasingly aging population due to rising average life expectancy and improved access to healthcare services, the incidence of skin cancer continues to increase worldwide, requiring more active interventions by dermatologists. Conventional treatment options for skin cancer include wide local excision, cryosurgery, radiotherapy, electrodessication, intraliesional injection (5-fluorouracil, interferon), systemic chemotherapy, and laser surgery. With these methods, however, it is difficult to check intraoperatively whether or not cancer cells have been completely removed.

Frederic E. Mohs developed Mohs micrographic surgery (MMS) in the 1930s. Since it was introduced into Korea in the early 1990s, the number of cases of skin cancer treated with MMS has been increasing dramatically. The MMS procedure consists of removing the visible tumor, tissue processing, and microscopic examination to check for residual cancer cells, histopathological readings of tumor margins and tumor mapping, additional excision of remaining cancer cells, and reconstructive surgery. Compared with other surgical interventions, MMS has the advantages of complete tumor removal with maximum preservation of the surrounding normal tissue, high complete cure rate, and low recurrence rate. Disadvantages of MMS include a longer procedure time compared with other treatments, and requirement of a specially trained dermatologist and lab personnel with special equipment.

Against this background, we examined the clinical features and major tumor-related variables in skin cancer patients who underwent MMS in our hospital from May 2010 to April 2015. Specifically, we examined the patients’ MMS-related clinical experiences and recurrence rates, and reviewed the preoperative scans to identify local and distant metastases of skin cancer. We also performed a stepwise analysis of the timeframe involved in different steps of the procedure in order to determine factors influencing operation length, which is considered the main drawback of MMS.
MATERIALS AND METHODS

1. Subjects

Over a 5-year period (May 2010–April 2015), we followed 293 patients who were treated using MMS and reconstructive surgery by the Skin Surgery Team of our hospital after being histologically diagnosed with skin cancer in the Department of Dermatology at Chosun University Hospital.

2. Methods

1) Clinical Evaluation

We examined each patient’s sex and age; location, type, size, and duration of the tumor; the number of excisions of tumor margins performed during the MMS procedure, reconstructive method after excision, and recurrence rate. For each patient, a preliminary computed tomography (CT) scan was performed to check if the tumor had metastasized. All patients made follow-up visits at postoperative months 1, 3, 6, and 12, and every 6 months afterwards.

2) MMS Procedure

(1) Preparation for surgery

In the outpatient surgery suite at the Department of Dermatology or hospital operation room, we mapped out the tumor site by outlining the tumor and marking excision margins with a surgical marking pen and took images. We anesthetized the surgical area by infusing a solution of 1% lidocaine with 1:100,000 epinephrine, then sterilized and draped the surgical area.

(2) Excision of tumor tissue

We resected the tumor along its margin and performed the first excision including a 2-mm margin (peripheral strip) and the outer layer of adipose tissue, followed by pressure dressing to stop bleeding. Prior to excision of the peripheral strip, we delineated the lesion by making incisions down to healthy tissue in 3 or 4 equal parts with a No. 11 scalpel blade.

(3) Mohs map drawing and histopathological interpretation

The excised tissue was laid on gauze and transferred to the histopathology lab for processing, where the margin was stained in different colors after being divided into 3, 4, or any number of equal parts (Davison Marking System, Bradley Products Inc., Minneapolis, MN, USA). A Mohs map was hand-drawn. The excised tissue was frozen and tangentially sliced so the peripheral and basal portions were aligned in the same horizontal plane. These histological slices were then cut in 4-μm sections and stained with hematoxylin and eosin. A pathologist examined prepared slides under an optical microscope for residual cancer cells, and the dermatologist was asked to help with reading of the tumor margins if a clear-cut interpretation was difficult to make.

(4) Residual tumor tissue

If the Mohs map indicated any areas with residual tumor tissue, additional excisions were made extending the corresponding margin in 2-mm increments. This process of map reading and additional excision was repeated until the peripheral and basal portions of the additionally excised tissue were completely free of tumor cells.

(5) Reconstructive surgery

Once the tumor was completely removed, we sterilized the surgical area, measured the size of the resultant surgical defect, took images, outlined the repair area with a surgical marking pen, and completely numbed the area with local anesthesia. We repaired the defect immediately after the MMS procedure using methods such as primary closure, local flap, and skin graft.

To calculate the average time taken per MMS and perform stepwise analysis of the total operation time, we divided the procedure into stages as follows: the first stage covered the steps from preparation for surgery to histopathological interpretation [(1)–(3)]. If the histopathological interpretation confirmed the presence of residual tumor cells, additional excision and histopathological interpretation [(4), (3)] were performed, and these steps were categorized as the second stage. Steps (4) and (3) were repeated until histopathological examination confirmed the absence of tumor cells; each repetition was categorized as the third stage, and so on. Reconstructive surgery was categorized as the repair stage.

3) Statistical Analysis

To examine the correlations between clinicopathologic variables in skin cancer, we performed an chi-square test at a significance level of 5%, and analyzed the results using SPSS ver. 13.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

1. Gender and Age Distributions

Of the total 293 patients, women (n=199, 68%) outnumbered men (n=94, 32%). The elderly (≥60 years) accounted for 83%, with the numbers of patients in their 60s, 70s, and 80s being 64, 106, and 65, respectively, followed by 50s (n=27), 40s (n=11), and 30s or younger (n=10) (Fig. 1). The mean age of all patients was 70.88 years. At 68.98 years, men were found
to develop skin cancer earlier than women (72.20 years) with statistical significance (p=0.014).

2. Tumor Type, Duration, and Size

Comparing the skin cancer cases by type, basal cell carcinoma (BCC) outnumbered squamous cell carcinoma (SCC) (57.3%, n=168 vs. 42.7%, n=125). The mean tumor duration was 42.5 months (range, 6–96 months), and the mean tumor size (long axis) was 13.74 mm (range, 7.8–50.1 mm).

3. Tumor Location

The most common tumor location was the facial area (237 cases, 80.8%), followed by extremities (34 cases, 11.6%), trunk (16 cases, 5.4%), and scalp (6 cases, 2.2%) (Fig. 2). Of lesions in the facial area, nose was the most common tumor site with 24.0%, followed by cheek (20.0%), around the eye (11.0%), forehead (8.0%), ear (7.0%), and chin (6.0%). In order to compare tumor distribution of left-side location to right-side location, we divided 196 cases after excluding 97 cases with central location into left-side and right-side lesions, which yielded proportions of 58.2% and 41.8%, respectively. Both male and female patients tended to develop skin cancer on the left side: men more markedly than women (62.0% vs. 54.6%), demonstrating a statistically significant gender difference (p=0.004). A higher left-side prevalence was observed when the left-side to right-side comparison was made on tumor locations in areas exposed to the sun, such as the face and upper extremities. Of 260 such cases, 84 cases with central location were excluded, and 176 cases were compared: 60.2% were located on the left side, showing a stronger left-side tendency than the comparison of all patients, with statistical significance (p=0.018).

4. Reconstruction of the Surgical Defect

Local flaps, with 234 cases (79.8%), were most frequently used for surgical defect reconstruction, followed by primary closure (38 cases, 13%), and skin grafts (21 cases, 7.2%). When comparing the frequencies of repair techniques by repair area, skin defects in the face were repaired most frequently with local flaps (57.6%), followed by primary closure, and skin grafts. Nonfacial surgical defects, such as those in the trunk, upper extremities, and scalp, were mostly repaired by primary closure (67.1%, 52.3%, 62.3%, respectively) (Fig. 3).

5. Number of the Staged Peripheral Margin Excisions

Of the total 293 cases, we analyzed 158 cases that had accurate records of all MMS surgical steps and the time taken for each step. The majority of cases required only the first stage (129 cases, 81.6%), and 24 cases (15.8%) and 4 cases (2.6%) underwent second and third excisions, respectively. Two of the 4 cases that underwent the third excision of the peripheral margin were SCC cases on the upper extremity and lip, respectively, and the remaining 2 cases were BCC on the face. The overall mean number of excisions was 1.21, with SCC outnumbering BCC (1.36 to 1.11).

6. Analysis of Clinical Features and Recurrence Rate by Tumor Type

Table 1 presents analysis of clinical features and recurrence rate by tumor type.
Table 1. Summary of clinical data in each type of nonmelanoma skin cancers

<table>
<thead>
<tr>
<th>Cell carcinoma</th>
<th>No. of cases</th>
<th>Patient mean age (yr)</th>
<th>Tumor size (mm)</th>
<th>No. of Mohs stage</th>
<th>Most common location</th>
<th>Recurrent rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCC</td>
<td>168</td>
<td>74.1</td>
<td>10.8</td>
<td>1.11</td>
<td>Face</td>
<td>0.59</td>
</tr>
<tr>
<td>SCC</td>
<td>125</td>
<td>73.2</td>
<td>14.7</td>
<td>1.36</td>
<td>Face</td>
<td>1.6</td>
</tr>
</tbody>
</table>

BCC, basal cell carcinoma; SCC, squamous cell carcinoma.

rates of the 293 cases by tumor type: 168 cases of BCC and 125 cases of SCC. The mean ages of patients with BCC (74.1 years) and SCC (73.2 years) were higher than the mean age of all patients. The mean tumor sizes for BCC and SCC were 10.6 mm and 14.7 mm, respectively. Both BCC and SCC occurred most frequently in the facial area, followed by the scalp, demonstrating that body parts exposed to the sun are at greater risk for developing skin cancer. The overall recurrence rate during the mean post-MMS follow-up period of 11.2 months (range, 6–48 months) was 1.0%, with 3 cases (1 BCC and 2 SCC cases) out of the total 293 cases. Case 1 was a patient with BCC on the forehead who developed a locally recurrent tumor in the 14th month post-MMS. There were no unusual findings, except that the patient had a history of cryotherapy on several occasions, and clinical images did not reveal any area suspected of cancer other than the primary tumor. Cases 2 and 3 were patients with SCC on the forehead and lower lip, respectively. They displayed no signs of recurrence up to the 13th and 15th post-MMS months, respectively, but SCC was confirmed in biopsies performed upon suspicion of recurrence in the 18th and 19th months, respectively.

7. Pre-MMS Radiography for the Detection of Metastatic Neoplasia

Of the total 201 patients who underwent a preoperative cervical CT scan to check for metastatic neoplasia, cancer was detected in 6 cases (2.9%). Three of them, patients with BCC around the right cheek, were found to have a tumor in cervical lymph nodes. One of the remaining 3 cases turned out a patient with SCC on the left-side upper lip, whose CT scan revealed a tumor in the left parotid gland. Other two patients had SCC on the left cheek and around the nose, respectively, whose CT scans revealed a tumor in cervical lymph nodes. We performed additional percutaneous needle biopsies of lymph nodes on 4 patients to check for metastasis, which yielded no specific findings. Biopsy could not be performed on 2 patients because they refused to undergo additional examination.

8. Analysis of MMS Timeframe

Of the total 293 cases, 158 cases had accurate MMS records and could thus be analyzed in terms of time. On average, it took 46.7 minutes (range, 32–102 minutes) for the first stage, 43.6 minutes (range, 32–61 minutes) for the second stage, and 40.0 minutes (range, 38–42 minutes) for the third stage (Fig. 4). The time taken for the first, second, and third stages by tumor type was 48.3, 44.1, and 40.0 minutes for BCC, and 44.4, 45.5, and 39.5 minutes for SCC. The overall mean time for the entire MMS procedure, including repair, was 131 minutes (range, 65–251 minutes). The mean time for reconstructive surgery was 76 minutes, accounting for 58% of the total operation time. Primary closure required the shortest time (30.3 minutes). Local flaps and skin grafts required 70.8 and 58.4 minutes on average, respectively. The time taken for Mohs mapping and histopathological interpretation in the first, second, and third stages were 30, 27, and 15 minutes, respectively, accounting for the greatest portions of their corresponding excision stages (65.2%, 62.7%, and 37.5%, respectively) (Fig. 5).
DISCUSSION

Recent years have witnessed a drastic increase in the incidence of skin cancer as a result of the rising elderly population, due to increasing average life expectancy and easier access to healthcare services. A study reported that in Korea, the elderly (≥65 years) accounted for 5.9% of the entire population in 1995, which increased to 9.7% in 1999 and is projected to reach 15.7% by 2020. Chun et al., who studied the same local population as our study, reported that skin cancer prevalence increased drastically from 1% during the period of 1987–1996 to 1.83% over the next 10 years (1997–2006), along with the mean ages of patients at the time of diagnosis (62.4 years). The number of MMS cases in Chosun University Hospital also increases year after year. The mean age of the patients examined in this study was 70.88 years, and men were found to develop skin cancer earlier than women (68.98 years compared to 72.20 years). A significant left-side prevalence (58.2%) was revealed by comparison of left-to-right side distribution of tumor location in 196 cases after excluding centrally located lesions. This left-side prevalence was more marked among men (62%). This left-skewed tendency of tumor location was also higher (60.2%) when examining 176 sun exposure cases, i.e., facial area and upper extremity. Old age and left-side prevalence may be explained by the region having the largest proportion of the nation’s elderly population and a high proportion of farming and fishing workers, possibly with asymmetrical ultraviolet accumulation. Other studies ascribed the left-side prevalence to sun exposure while driving, but the influence of driving is not considered to be substantial in this study since most of the patients were in their 60s and older.

Treatment choice for skin cancer can be made by judgment and preference of the medical team and patient, taking into account patient factors (sex, age, general conditions) and pathological factors (tumor type, histological subtype, location, and size). In most cases, surgery is the first-line treatment, and MMS is recommended as the best treatment option. MMS allows a 100% check of tumor margins showing asymmetric growth to different direction and complete tumor removal, increasing the cure rate. Rowe et al. reported that the 5-year recurrence rate of primary BCC is 1% when treated with Mohs surgery, and 8.7% when treated with non-Mohs techniques. The recurrence rate for cases examined in this study was 1.0% of the total cases (3 of 293), 0.59% of BCC cases (1 of 168), and 1.8% of SCC cases (2 of 125). The reasons for the lower recurrence rate compared to earlier studies are as follows: (1) advanced surgical and histological mapping skills, with MMS becoming the more common treatment of choice, (2) more accurate tumor margin readings by pathologists more familiar with the MMS histopathological interpretation technique, and (3) the shorter follow-up duration of this study compared with other studies. Moreover, MMS was reported to reduce surgical scars or functional restrictions because it preserves more normal tissue than other surgical methods; for example, it was reported that MMS excisions had 41% less tissue loss than simple excisions. Another advantage of MMS is that it is performed under local anesthesia, thus preventing difficulties associated with general anesthesia in elderly patients, who are at the highest risk for developing skin cancer.

In 2009, Casey et al. cited a report by the American Society for Mohs Surgery (ASMS) stating that MMS was the most commonly performed surgery for BCC (72.3%) and SCC (25.6%), with the proportion of the latter on the increase. The most common tumor location was the face (67%), most frequently on or around the nose (28%). This is consistent with the results of our study, which determined the frequencies to be 57.3% for BCC and 42.7% for SCC; 80.8% for the face and 24.0% for the nose.

Primary closure, local flaps, and skin grafts are efficient post-MMS repairs of skin defects. Repair choice depends on surgical experience and preference. A thorough understanding of anatomical structure and mastery of basic skin surgery techniques are required, and oncologic, functional, and aesthetic aspects should be taken into account. Primary closure can be chosen if the skin defect is small in size and thus does involve changes in surrounding tissue or dysfunction. Local flaps are commonly used if defects are too large for primary closure, and skin grafting is applied in cases of very large defects because a local flap may not harmonize with the surrounding area in terms of color and texture and the resurfaced area may be depressed. Local flap is the treatment of choice for facial defect reconstruction due to its superior aesthetic outcome, because the color, texture, thickness, and sebaceous quality of the flap are similar to those of defect tissue due to proximity of donor and recipient sites and availability of sufficient volume. In our study, local flap was used most frequently (234 cases, 79.8%), followed by primary closure (38 cases, 13%), and skin graft (21 cases, 7.2%). Reconstruction surgery made up the largest portion of the total operation time (76 minutes on average, 58%): primary closure required the shortest time (30.3 minutes), followed by skin graft (58.4 minutes), and local flap (70.8 minutes). The numbers of the first, second, and third stages in the 158 cases (out of 293 total cases) having accurate records of MMS procedure and time were 129 (81.6%), 25 (15.8%), and 4 (2.6%), respectively. The mean number of Mohs stages was 1.21: 1.11 for BCC and 1.36 for SCC, which are lower than the values from a previous study (1.7 and 1.84, respectively). The reduced number of excisions may be ascribed to the increased early detection rate and thus higher rate of clearly delineated lesions from growing awareness of skin.
cancer among patients and caregivers under increasing influence of mass and social media, and increased access to dermatology clinics. Additionally, the MMS technique applied in our hospital, in which the visible tumor is completely removed preliminarily instead of using the traditional method of debulking the central part of the tumor, may have contributed to reducing the MMS stages.

Foreign reports estimate the rate of SCC metastasis to other organs at a range of 0.1%–9.9%. According to a Korean study, only 1 patient showed cervical lymph node metastasis in preoperative imaging exams out of 102 patients scheduled for MMS, yielding a metastatic rate of 0.98%. In our study, 201 patients underwent head and neck CT scans prior to MMS, which revealed 5 cases of tumor in cervical lymph nodes and 1 case of tumor in the left parotid gland; however, they were not confirmed as metastasized tumors. Benedetto and Poblete-Lopez noted that preoperative scans should be performed depending on tumor size, location, and duration, especially for cases in which skin cancer is firmly attached to subcutaneous tissue or bone. In particular, given that the post-MMS cure rate for SCC spread to lymph nodes is as low as 16%, such cases require continuous follow-up. Of the 6 cases that showed abnormal findings in CT scans, 4 were cancer of the cheek.

The mean operation time in our study was 131 minutes (range, 65–251 minutes), confirming that MMS takes longer than other surgical methods. Broken down in stages, the times taken for the first, second, and third stages were 46.7, 43.6, and 40.0 minutes, respectively, with Mohs mapping and histopathological interpretation accounting for 65.2%, 62.7%, and 37.5% of each excision stage. These results from the reduced time for each MMS stage and increased time for corresponding histopathological interpretation, as compared to the study by Mun et al. In the cases examined in our study, the total operation time was reduced because each MMS stage took less time due to anesthesia being performed prior to lesion sterilization and draping, thus reducing waiting time for the hemostatic effect of the local anesthetic solution, and the surgeon reading tumor margins only when the pathologist was unsure. The reduced time for Mohs mapping and histopathological interpretation in comparison with previous studies may be ascribable to the timeframe set for MMS in our department. We usually start MMS at 2 p.m. By that time, the lab has finished most of the frozen sections referred from cancer surgery and can thus produce and read slides immediately upon receiving a Mohs map. The time will be further reduced if dermatologists can be certified for both surgery and histopathological interpretation in line with the tradition of MMS.

The limitation of this study is that we analyzed the procedures and outcomes of a single surgery team in 1 hospital. Despite this limitation, this study is significant in that it reaffirmed MMS as the best treatment option for skin cancer, and that data from head and neck CT scans of skin cancer patients along with detailed operation time analysis will increase use of MMS in Korea and accumulation of MMS-related data.

Conflict of Interest Disclosures: The researchers claim no conflicts of interest.

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REFERENCES