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Challenges and opportunities for Mohs surgery implementation in African healthcare systems

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Abstract

Background Skin cancer in African countries results primarily from exposure to high ambient ultraviolet radiation. It is an emerging public health issue with limited improvement in management services. Mohs surgery, a renowned surgical procedure in the treatment of skin cancer, involves exact tumor excision along with horizontal frozen tissue examination. It is known to minimize the defect size and improve patient outcomes. Therefore, Mohs surgery is highly effective for almost all nonmelanoma skin cancers. Despite its proven potential, the implementation of Mohs surgery in Africa faces various limitations. This commentary seeks to provide insights into the current threats and opportunities surrounding the execution of Mohs surgery in African healthcare systems. The role of governments, healthcare professionals, and international organizations is also highlighted in this paper.

Methods A literature search was conducted by retrieving articles from PubMed and Google Scholar. Previous articles that discuss skin cancer, Mohs surgery, and cancer in Africa were analysed to understand the implementation aspects of Mohs surgery in Africa.

Results The implementation of Mohs surgery in Africa is very limited due to challenges such as inadequately trained healthcare professionals, costs associated with the surgery, and cultural beliefs and misconceptions. Nevertheless, telemedicine has been used in surgical consultations regarding the postoperative management of patients who undergo Mohs surgery.

Conclusion Despite advances in medicine, African dermatological health care remains underdeveloped. Therefore, increased investment in healthcare training, infrastructure development, and more African-based skin cancer studies are necessary and paramount factors for the expansion and accessibility of Mohs surgery in Africa.

Keywords Africa, Mohs surgery, Skin cancer, Carcinoma, Dermatology, Healthcare system

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Introduction

Mohs surgery is a delicate technique used to resect cutaneous tumors, and it involves tissue analysis during surgery to achieve a tumor-free area with minimal normal tissue resection [1]. It is indicated for large tumors (>2 cm), tumors with irregular borders, tumors with aggressive histology (poorly differentiated squamous cell carcinoma), and tumors that invade the bone or perineural sheath [2]. Additionally, tumors at locations with a high risk of recurrence, such as those located at the nose, lips, ears, periorbital region, periocular region, and nasolabial folds, can also benefit from Mohs surgery [3]. Moreover, it has a significant role in esthetic and functional sparing when used to remove tumors that attack the genitals, nails, and face [4]. In addition, it is appropriate for patients with immunosuppression, environmental exposure to carcinogens, or a genetic predisposition to cutaneous malignancies [2].

Mohs surgery was discovered by Dr Frederic Mohs in the 1930s, during which he discovered that the use of 20% zinc chloride on the skin of rats conserves the histology and helps during microscopic analysis. Then, he applied it to human skin and left it to fixate in situ overnight [5]. In 1941, his technique was successful in more than 400 patients; however, it was controversial due to significant inflammation caused by chemical fixation [5, 6]. In the 1950s, he was obliged to use the frozen tissue technique on a recurrent eyelid tumor to gain time during the filming of his procedure. Less inflammation was noted with this technique, so he adopted it [7]. In the 1960s, Dr. Theodore Tromovitch reported less pain and inflammation by using the "fresh tissue technique", which is now the optimal technique in microscopically controlled surgeries [8].

Skin cancer is underexplored in Africa, and people there are neither well educated about it nor do they receive the care required [9]. Cutaneous melanoma, squamous cell carcinoma (SCC), and basal cell carcinoma (BCC) are the most prevalent skin tumors, for which melanoma has the worst prognosis and can be fatal if untreated. However, squamous cell carcinoma and basal cell carcinoma can significantly deform the skin [10]. Typically, basal cell carcinoma and squamous cell carcinoma rarely affect sores, palms, or mucous membranes but often attack other UV light-damaged parts of the skin, such as the neck or head. Although rare, they can metastasize, destruct and disfigure skin tissues, leading to death in cases of delayed or inadequate treatment. Immunosuppressed patients are at a high risk of developing SCC due to the increased incidence of metastasis associated with immunosuppression [11, 12]. Mohs surgery is currently the standard of care for cutaneous tumors, with maximum tumor resection and minimal healthy tissue resection. However, data concerning its implementation in Africa are not available. Thus, this commentary seeks to provide insights into the current threats and opportunities surrounding the execution of Mohs surgery in African healthcare systems.

Landscape of skin cancer in Africa

Human anatomy is largely uniform across populations, with variations occurring on an individual basis. Among the external characteristics, differences in features such as skin color or tone are evident. While the people of color (POC) pay less attention to skin cancer, its mortality rates tend to be higher due to delays in diagnosis, intervention, and treatment [13]. In South African populations, basal cell carcinoma, squamous cell carcinoma, and melanoma are more prevalent in individuals with light skin than in those with dark skin [14]. Research estimates that POC has an inherent sun protection factor (SPF) of 13.4, which is approximately ten times lower in individuals with light skin [13]. This high SPF is attributed to increased melanin and dispersed melanosomes in their skin, allowing for more effective absorption and deflection of harmful UV rays. Consequently, compared with white individuals, the POC tend to experience fewer cases of skin cancer. However, factors such as prolonged UV exposure in certain occupations, organ transplantation, HIV infection, radiation therapy, and phototherapy can increase the risk of skin cancer regardless of skin tone [13]. Treatments for skin cancer have evolved such that these therapies include surgery, radiation, chemotherapy, immunotherapy, and targeted and photodynamic therapy. Regardless of the chosen treatment modality, an upwards trend in morbidity and mortality rates is evident, attributable to reduced awareness initiatives, compounded by the socioeconomic challenges faced by patients, often resulting in delayed clinical presentations and manifestations of symptoms impacting daily functioning [13].

Mohs surgery: a closer look

The Mohs surgery technique is performed on an outpatient, and it can be performed by a surgical dermatologist who can excise the tissue and examine it under a microscope. It involves, first, outlining the tumor, followed by the administration of local anaesthesia around a visible tumor, and marking superficial etch marks around the tissue layer [15]. Thereafter, the tumor is excised using a surgical blade whereby a thin layer of tissue around and deep to the debulked sites is removed at a 45-degree angle. The removed layer of tissue is then cut into halves or quadrants, which are then colored and numbered for easy identification. Then, the tissue is pressed flat to align the epidermal and the deep edges. The tissue is then frozen, cut, and processed in a horizontal direction. Unlike the traditional vertical tissue processing, which involves examining a small section of the tumor margin, Mohs'

horizontal tissue processing allows microscopic examination of approximately 100% of the peripheral and deep tissue margin on the same tissue section. The removed tissue can be stained either with hematoxylin & eosin (to identify keratinization and necrosis, which are good for SCC) or with toluidine blue (to identify mucopolysaccharides, which are good for BCC) [16]. If a residual tumor is detected, the surrounding tissue is removed based on tumor detection on the Mohs Map. To ensure negative histology of the skin, the process is repeated. After successful tumor removal, the defect is allowed to close either by second intention healing or by primary closure. Surgical dermatologists can even use flaps or grafts to close the defect [15] (Fig. 1).

Another method of skin tumor resection is wide local excision (WLE). According to the American Society for Dermatologic Surgery, wide local excision (WLE) technique resects a tumor with surrounding normal tissue in a "football-shaped ellipse", and then the tissue is examined by a pathologist. It is used for low-risk SCC and BCC tumors, and for early-stage melanoma [17]. Mohs has achieved great success in treating cutaneous tumors. Studies have shown that the 5-year cure rates for Mohs surgery are 99% for primary BCC, 94.4% for recurrent BCC, 92–99% for primary SCC, and 90% for recurrent SCC [18–21]. The Mohs technique aims to achieve a tumor-free zone with minimal healthy tissue resection; thus, it has a significant functional and aesthetic sparing, especially for tumors involving the head, neck, and genitals [15]. However, advanced cases may result in a remarkable postexcision defect. Reconstruction after Mohs is never performed before confirming clear margins. It may be performed on the same day or delayed [18, 19]. Additionally, the method of reconstruction depends on the skills of the surgeon, the size, and the location of the defect. It also depends on the patient's health status and preferences. Thus, reconstruction post-Mohs micrographic surgery (MMS) is complex and requires a multidisciplinary approach to achieve optimal results [20]. Compared with MMS, traditional surgical excision techniques whether performed in ambulatory surgical centers (ASC) or offices, are more expensive than MMS by 12% and 27%, respectively [21]. This makes MMS more cost-effective in the long run than traditional surgical excision, which may even require a re-excision procedure (Table 1).

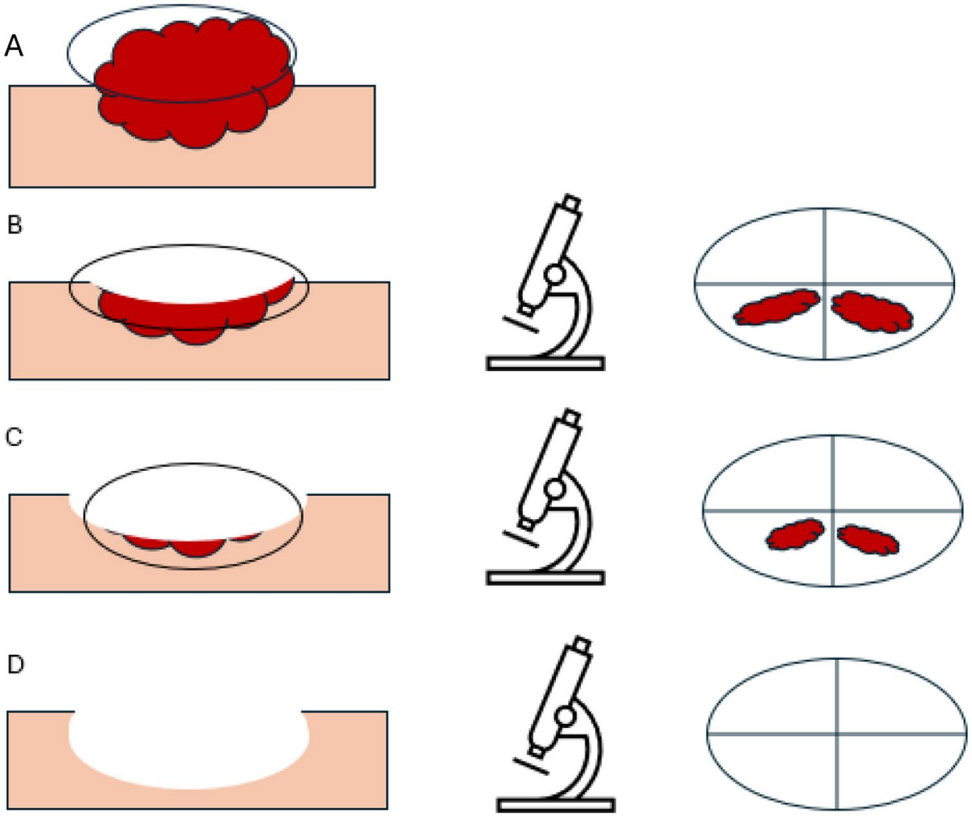

Fig. 1 Description of gradual tissue resection via the Mohs technique until establishing a tumor-free zone is established. **A**: Debulking, **B**: Remove a thin layer of tissue around and deep to the debulked site, and then examine, under a microscope, the segmented mapped sample, **C** & **D**: repeat the same process until a free tumor area is formed

Table 1 Differences between wide local excision (WLE) and micrographically oriented histographic surgery (Mohs)

Parameters	Excision Technique		References
	WLE	Mohs	
Indications	SCC and BCC in low-risk sites (lower limbs) Early melanomas	Tumors at high-risk sites (eye, ear) Recurrent tumors Tumors at irradiated skin or chronic wounds Aggressive tumors Invasive tumors Tumors > 2 cm Immunosuppressed patients	[2, 3]
Incision mode	Bread loaf excision (elliptical incision that involves the tumor and surrounding tissue, involves < 1–2% of the specimen margin)	Start by resecting the tumor and then gradual removal of surrounding tissue to involve a full range of tumor extension	[1, 17]
Microscopic analysis	By the pathologist	By Mohs surgeon	
Melanoma recurrence risk	7%	< 1%	[22]

Discussion

Barriers to Mohs implementation in the African healthcare system

Mohs surgeons must be able to maintain deep wound orientation involving muscle and bone. Additionally, they must be able to interpret various tissue processing artifacts so that tumors can be mapped accurately, as technical errors have been the leading cause of local recurrences in MMS [3]. Mohs surgeons must be trained to manage all aspects of small tumor excision as well as excisions of large, deeply invasive tumors that may affect critical structures[23]. Thus, surgeons who are well trained and competent in conducting Mohs surgery are needed in the operating room, a case which is difficult to find in African healthcare systems due to the lack of specialised medical doctors. Furthermore, frozen section immunostaining is a method used in a variety of tumors and has become more widespread. However, this method requires a lot of time and it is expensive. For instance, the cost of reagents needed per slide is approximately $20. Moreover, the extent of automation desired and the laboratory personnel need to prepare extra slides must be considered because they influence further costs [24]. In addition, due to a lack of training in African health systems, interpreting immunostaining results can be difficult and can yield false-positive results in some cases. Thus, an experienced histology technician is needed to produce onsite horizontal frozen sections and attain complete tissue samples for microscopic examination [25]. Besides, low socioeconomic status is strongly associated with later stages at melanoma presentation and lower survival rates than higher socioeconomic status is [26]. The key cost elements to be taken into account when diagnosing and describing treatments for skin cancer include initial and subsequent consultations with general practitioners or specialists, pathology, and various treatment options such as surgical removal, topical treatments, radiation therapy, and photodynamic [27].

Table 2 Boundaries limiting healthcare implementation of Mohs surgery in Africa

Barriers	Examples	References
Healthcare system	• Lack of well-trained surgical physicians • Lack of good equipment and technologies	[25]
Funding and costs	• Cost of skin cancer management is approximately 15.7 million US dollars per a year • Lack of funds to implement improved imaging and surgical technologies	[34]
Cultural beliefs	• Skin cancer cannot happen to dark skin. • Sunscreen is not needed and cannot prevent skin cancer	[24]

Furthermore, cultural beliefs and perspectives about skin cancer and its treatment affect the implementation of Mohs surgery in Africa. People with inherent dark skin tend to believe that they are immune to skin cancer and that the use of sunscreen is insignificant [28]. Moreover, the use of medical care and treatment for skin cancer is foreseen as a sign of weakness, which discourages people from visiting healthcare centres [29]. Populations from low- to middle- income countries also have limited knowledge about skin cancer and believe that they are at a lower risk of developing skin cancer because of their lifestyle that involves continuous sun exposure and/or because they lack a family history of cancer [30]. They also frequently characterise skin reactions to intense sun exposure as "irritation" or "darkening," rather than "burning" or "tanning", and this variance in terminology might signify discrepancies in how different skin types respond to sun damage [31, 32]. While these beliefs and perspectives might hold reasonable, addressing unfamiliarity with the term melanoma, its prevalence, distribution, and presentation in an African context remains untapped. Increased education regarding the risks, presentations, and prevention of skin cancers among populations may provide an opportunity for better management of skin cancer [27, 33] (Table 2).

Opportunities for the integration and growth of Mohs in Africa

Multinational efforts in several areas can allow Mohs growth and integration into the healthcare system in Africa. International support is essential and can offer help in multiple aspects. International partnerships have the potential to improve any technique through mutual learning and training. For instance, the Global Partnerships for Education and Care (GPEC) is a program established by the International League of Dermatological Societies, and it aims to pair dermatology departments internationally to allow bidirectional knowledge exchange. This, in turn, leads to achieving best dermatologic education and care. It supports the whole entity of a dermatological department by providing training and allowing knowledge sharing [35]. Mohs surgeries are performed by Mohs surgeons, who are surgical dermatologists able to resect the tumor and examine it under a microscope. Training in MMS involves all steps of the procedure, from resecting the tumor to preparing the tissue and finally to examining it microscopically. Moreover, Mohs surgeons should be well oriented towards complex neurological and vascular anatomy to optimize the results of resection and reconstruction. Dermatologists have greater insight into pathology and skin oncology than surgeons do. In the U.S., after the completion of ACGME-accredited residency in dermatology, residents usually receive a 1-year training program in the Mohs technique, which helps them develop skills in clinical and pathological tumor assessment [36, 37]. Adopting such programs can thus produce high-quality Mohs surgeons in African health systems.

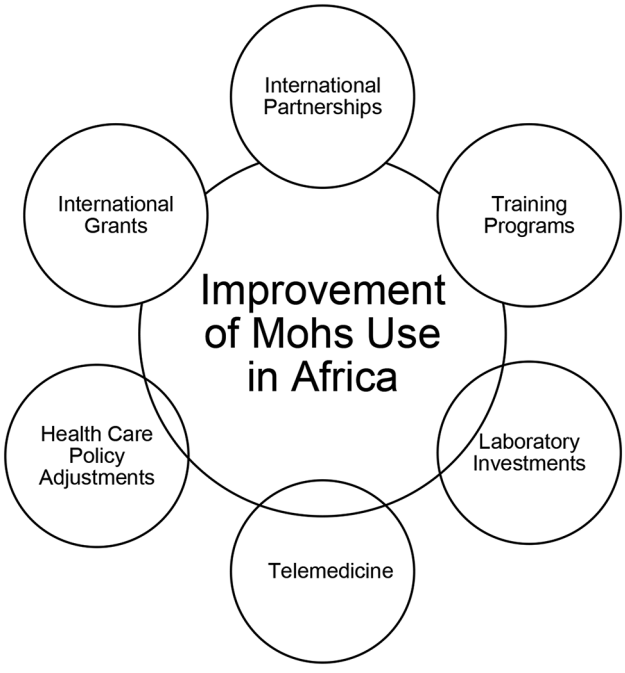

Fig. 2 Factors that can improve Mohs use in African health systems

To achieve the best Mohs technique in Africa, which involves crucial tissue preparation and pathological examination, there is a need to invest in laboratory equipment that provides high-quality specimens. To assemble an effective Mohs laboratory, not only are enough funds needed, but also medical experts in the field are needed. The financial need will continue to ensure a continuous supply of reagents, tissue processing equipment, and qualified technicians. Additionally, there is a need to apply quality assessment measures to ensure adherence to the protocol and correct functioning. The COVID-19 pandemic promoted the use of telemedicine in various areas of medicine. One of them is Mohs surgery, for which a pilot study was performed by Maruthur M et al. to assess the use of telemedicine in such a procedure. It was found that 86.1% of responding Mohs surgeons used telemedicine during the pandemic for surgical consultations, "spot checks", and postop handling [38]. This can aid in applying the MMS technique under guidance in areas of poor experience.

The Ministry of Health can contribute to improving dermatologic care by investing resources in training healthcare providers. This will increase their knowledge and improve their attitudes in handling dermatologic diseases [35]. In addition, improving access to dermatological screening and awareness in Africa will lead to early diagnosis, early treatment, and better prognosis of cutaneous cancers. Moreover, preventive measures can be addressed through campaigns that target the general population broadly and high-risk people (people with light skin tone, oculocutaneous albinism, or HIV+) specifically [39]. These implications require a large amount of money and resources, which are barely available in Africa. Therefore, applying for international funds and grants is highly encouraged, especially in procedures such as Mohs, which is very cost-effective in comparison with other conventional techniques. Such grants can help establish high-quality centers with high standards of care. Moreover, they can help low-income Africans gain access to affordable and high-quality care, thus aiming to achieve equal care access (Fig. 2).

Case studies

Mohs micrographic surgery (MMS) has emerged as a crucial surgical modality that has replaced conventional wide excision approaches in the treatment of cutaneous malignancies, particularly squamous cell carcinoma. By facilitating precise margin assessment and tissue sparing, MMS mitigates the extent of tissue resection, thereby diminishing the morbidity and mortality rates associated with skin cancer. A recent investigation conducted at the University of Pennsylvania studied the clinical

outcomes of individuals afflicted with squamous cell carcinoma affecting both the hand and wrist regions. They encompassed patients subjected to MMS coupled with reconstructive procedures for squamous cell carcinoma of the hand and wrist. The outcomes revealed a notable reduction in postoperative complications, preservation and restoration of upper extremity functionality, and a concomitant decline in the incidence of adverse events [40]. Furthermore, a retrospective study by Bascone et al. reported a promising reconstruction approach that incorporates a dermal Integra Bilayer Wound Matrix for patients who had undergone MMS of the facial region, particularly the forehead and nose. In this study, the approach was associated with low reoperation rates and complications while causing successful reconstruction even for large defects of approximately 27 cm^2 [41]. Although there is still a paucity of case studies that have been carried out by African health systems, the existing studies on the success of MMS serve as a fact and motivation. They may facilitate the effective implementation of Mohs surgery in Africa, in which health professionals refer to them to make informed decisions for optimal practices for the treatment of skin cancer.

Future directions

Surgical interventions are at risk for postoperative complications. Mohs micrographic surgery, although renowned for its efficacy in treating skin malignancies, is not entirely exempt from such incidences. Studies have reported favourable outcomes, such that there was no incidence of major complications, but reported minor complications were reported at a rate of 2.6% [41]. Additionally, patients who undergo Mohs surgery report an average postoperative pain level of 1.99 on a numerical rating scale, which is indicative of a perceptible but generally manageable discomfort immediately after the procedure [41]. As a result, it is highly tolerant and safe. A thirteen-month prospective study conducted at the Mersey Regional Center for Mohs Surgery in the UK concluded that, compared with patients who underwent conventional excision and reconstruction, 80% of patients who underwent Mohs Surgery benefited from reconstruction [42].

The number of cancer cases in Sub-Saharan Africa is increasing. It is predicted that the cancer burden by 2030 will increase to as high as 85% [43]. As a result, creating a cancer control strategy that includes cancer awareness, cancer advocacy, cancer training and education, strengthening health systems, and creating a multidisciplinary cancer research center, especially for skin cancer, would enhance prevention, screening, and treatment and improve patient outcomes and quality of life [43]. Moreover, funding a capacity-building research program on skin cancer in Africa, such as the Men of African Descent and Carcinoma of the Prostate Consortium (MADCaP) and the Women of Africa Ancestry Breast Cancer Consortium, would help in reaching advancements in skin cancer occurring in African populations.

Conclusion

The Mohs technique aims to achieve a tumor-free zone with minimal healthy tissue resection. Thus, it is significantly more functional and aesthetically safer than wide local excision, especially for treating tumors that attack the head, neck, and genitals. In addition, this form of treatment provides the patients with high cure rates, particularly when complex and recurrent skin cancer is treated. It also allows much tissue conservation and limits patient relapse and follow-up. Mohs surgery has attained statistical significance for the treatment of basal cell carcinoma, squamous cell carcinoma, and other tumors. However, its implementation in Africa is very limited due to challenges such as inadequately trained healthcare professionals, costs associated with the surgery, and cultural beliefs and misconceptions. Healthcare policy adjustments, establishing international partnerships, and increasing professional training and laboratory investments, among other factors, could substantially facilitate the implementation of Mohs surgery in Africa. Integrating Mohs surgery in African dermatological healthcare is an important step in enhancing skin cancer patients' outcomes, improving diagnostic accuracy, and increasing the capacity of healthcare providers. This, in turn, can contribute to the overall improvement in dermatological care on the continent. While studies on skin cancer in Africa are still inadequate, this is a transformative opportunity that African governments, healthcare professionals, and international organizations should take into consideration to increase the degree of dermatological care and address the increasing burden of skin cancer that could affect Africa.

Abbreviations

SCC	Squamous Cell Carcinoma
BCC	Basal Cell Carcinoma
SPF	Sun Protection Factor
WLE	Wide Local Excision
MMS	Mohs Micrographic Surgery
ASC	Ambulatory Surgical Center
GPEC	Global Partnerships for Education and Care
POC	People of Color

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Author contributions

O.U: Conceptualization, Project administration, Writing-review and Designing. All authors: Data collection and Assembly. S.I: Reviewed and edited the first draft. M.W: Reviewed and edited the first draft. Manuscript writing: All authors. O.U: Reviewed and edited the final draft. Final approval of manuscript: All authors. Figs. 1 and 2. were analyzed and edited by S.I. Table (1) was designed

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