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# Surgical Approaches for Complex Skin Defects in Patients with a History of Skin Cancer

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**ABSTRACT**

Introduction: The treatment of complex skin defects in patients with a history of skin cancer requires a multidisciplinary and individualized surgical approach. These cases often involve challenging reconstructions, due to the extent of the resections and previous skin conditions. Objective: A narrative literature review was carried out with the aim of compiling and critically analyzing the surgical approaches described in the literature for the reconstruction of complex skin defects in patients with a history of skin cancer and comparing different surgical approaches used to treat complex defects related to skin cancer. Methodology: The review followed systematic steps to ensure the comprehensiveness and quality of the data collected. Techniques such as skin grafts, local and regional flaps and, in more severe cases, microsurgical flaps, were evaluated and discussed based on factors such as the location of the defect, type of cancer, comorbidities and the patient's quality of life. Results and Discussion: Surgical planning includes the analysis of aesthetic and functional aspects, as well as the need for adequate oncological control. In addition, the management of irradiated tissues or those previously submitted to surgery requires additional care to ensure vascularization and avoid complications. Conclusions: Advances in technology, such as 3D simulation and biomaterials, have contributed to better clinical and aesthetic results.

**Keywords:** reconstructive surgery, complex skin defects, skin cancer, flaps, skin grafts, oncologic reconstruction, multidisciplinary approach.

## INTRODUCTION

The incidence of skin cancer has increased globally, making it one of the most diagnosed types of cancer. This increase is largely attributed to greater exposure to ultraviolet (UV) radiation, mainly due to human behavior, such as spending more time outdoors and inadequate use of sun protection. Additionally, the reduction of the ozone layer has intensified UV radiation levels in several regions, especially in areas with high sun exposure, such as Australia and New Zealand (GLOBOCAN, 2020; Leiter et al., 2020).

Among the types of skin cancer, melanoma and non-melanoma carcinomas stand out, such as basal cell carcinoma (BCC) and squamous cell carcinoma (SCC).

While BCC is the most common and has a low mortality rate, melanoma is less prevalent but more aggressive, accounting for the majority of skin cancer-related deaths. Population ageing, combined with advances in diagnostic methods, is also contributing to the increase in the number of cases, especially in developed countries (Narayanan et al., 2010; Bray et al., 2018).

Regions with a high incidence, such as Oceania, North America and parts of Europe, stand out in epidemiological records due to awareness and access to diagnosis. However, developing countries faces challenges related to underreporting and limited access to specialized services. Global prevention strategies, including educational campaigns on sun protection, early detection and monitoring of suspicious lesions, are essential to mitigate the impact of the disease (GLOBOCAN, 2020; Diepgen & Mahler, 2002).

The reconstruction of complex skin defects after surgical resection, especially in oncological cases, presents significant challenges for the medical team. These defects often involve the loss of tissues with both functional and aesthetic importance, requiring surgical approaches that reconcile satisfactory results in both aspects. The choice of the ideal technique depends on the location of the defect, the quality of the remaining tissue and the patient's comorbidities. Skin grafts and local flaps are often used, but have limitations in extensive defects or irradiated areas (Weber et al., 2017).

The management of tissue that has been irradiated or previously undergone surgery is particularly challenging due to fibrosis and reduced vascularization, which increases the risk of necrosis and infections. In these cases, advanced techniques, such as free microsurgical flaps, can be

employed to ensure better vascularization and supply large volumes of tissue. However, these procedures require specialized infrastructure and adequate training, as well as being associated with high costs and longer surgical times (Demirkan et al., 2019).

Another important challenge is related to aesthetic and functional integration, especially in visible areas such as the face and hands. In addition, psychological factors, such as the patient's acceptance of the appearance, also influence surgical planning (Demirkan et al., 2019).

The use of emerging technologies, such as 3D printing for surgical simulation and advanced biomaterials, has shown potential to improve clinical outcomes and reduce complications, but their application is still limited by availability and cost (Lonie et al., 2016).

## OBJECTIVE

To analyze and compare different surgical approaches used to treat complex defects related to skin cancer.

## METHODOLOGY

This article constitutes a narrative literature review, with the aim of compiling and critically analyzing the surgical approaches described in the literature for the reconstruction of complex skin defects in patients with a history of skin cancer. The review followed systematic steps to ensure the comprehensiveness and quality of the data collected.

**Search strategy**

The search was conducted in the scientific databases PubMed, Scopus, Web of Science, and SciELO. The following controlled and non-controlled descriptors were used in different combinations:

“Surgical approaches”

“Skin cancer”

“Complex skin defects”

“Reconstructive surgery”

“Oncological reconstruction”.

The terms were combined with Boolean operators (AND, OR) to refine the results. The search included articles published in English, Portuguese and Spanish.

### *Inclusion and exclusion criteria*

**The review included**

- ✓ Original articles, systematic reviews, and case series addressing surgical techniques for complex skin defects in patients with skin cancer.
- ✓ Publications presenting clinical data, technological advances or comparative analyses of reconstructive techniques.
- ✓ The following were excluded
- ✓ Articles with no full text available.
- ✓ Studies involving only non-surgical reconstructions or related to other types of non-cutaneous cancer.
- ✓ Single case reports with no generalizable relevance.

**Study selection**

Of the total number of articles identified, the titles and abstracts were independently assessed by two reviewers, and the eligible articles were read in full. In cases of disagreement, a third reviewer was consulted. The final selection included articles considered relevant and of high methodological quality.

### *Data analysis and synthesis*

The data extracted included:- Types of skin cancer (melanoma and non-melanoma carcinomas).- Location and extent of defects.- Surgical techniques used, such as skin grafts, local, regional and microsurgical flaps.- Clinical, functional and aesthetic results.- Complications associated with the different approaches.

The synthesis was carried out qualitatively, grouping the data into thematic categories that would allow discussion of the main advances and challenges in the reconstruction of skin defects.

**Limitations**

It is recognized that the absence of quantitative evaluation criteria and the inclusion of heterogeneous articles may limit the generalizability of the results. However, the narrative approach provided a comprehensive overview of available surgical strategies and their applications.

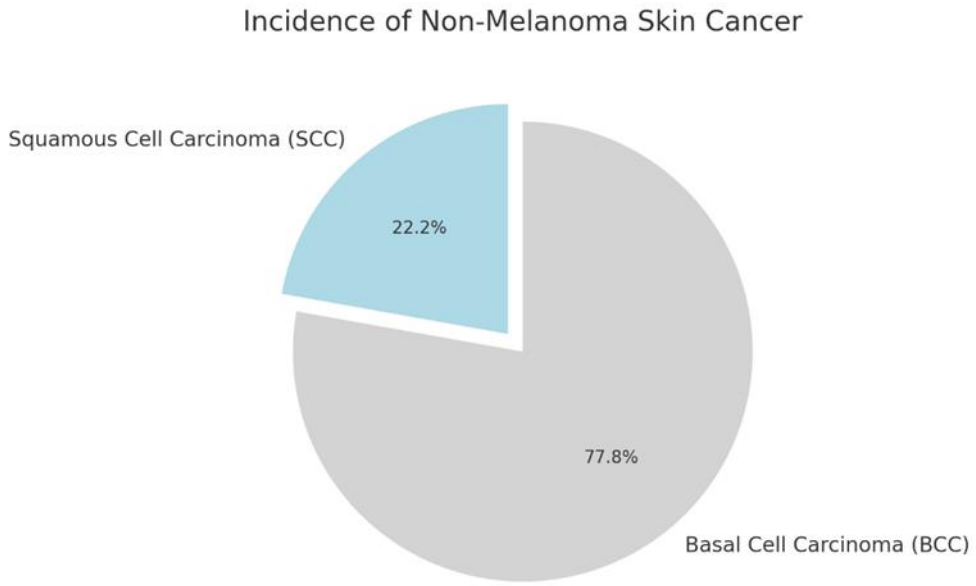
This methodology sought to provide a comprehensive and up-to-date overview of surgical approaches for the reconstruction of complex skin defects in patients with a history of skin cancer, contributing to clinical practice and future research in the area.

## RESULTS AND DISCUSSION

Skin cancer is the most prevalent neoplasm worldwide, with increasing incidence rates due to greater exposure to ultraviolet (UV) radiation and population ageing. The two main groups of skin cancer include non-melanoma skin cancer, represented by basal cell carcinoma (BCC) and squamous cell carcinoma (SCC), and melanoma, a rarer but more aggressive type. Globally, BCC is the most common type of skin cancer, accounting for approximately 77.8% of skin cancer cases. Its indolent nature and low metastasis rate contribute to a high cure rate when treated early (GLOBOCAN, 2020; Leiter et al., 2020).

Squamous cell carcinoma (SCC) is the second most common type of skin cancer, accounting for around 22.2% of non-melanoma skin cancer cases. Unlike BCC, SCC is more prone to local invasion and metastasis, especially in advanced cases or in immunosuppressed patients. Chronic exposure to UV radiation, as well as factors such as smoking and human papillomavirus (HPV) infection, are associated with an increased risk of developing SCC. Men and individuals with fair skin are the most affected by this type of cancer (Narayanan et al., 2010; Rogers et al., 2015).

These data are shown in GRAPH 1.




Graph 1. Incidence of the main types of non-melanoma skin cancer: basal cell carcinoma (BCC) and squamous cell carcinoma (SCC). Source: GLOBOCAN 2020, Global Cancer Observatory - International Agency for Research on Cancer (IARC).

Melanoma, although less common, is the most lethal type of skin cancer, accounting for around 1% of skin cancer cases, but responsible for the majority of deaths related to the disease. It originates in melanocytes and is strongly associated with intermittent and intense exposure to UV radiation, especially during periods of sunburn. Genetic factors, such as a family history of melanoma and mutations in the BRAF and NRAS genes, also play an important role. Early diagnosis is essential to reduce mortality, with surgical treatment being the main approach in the early stages (Bray et al., 2018; Whiteman et al., 2016).

Wide resections in skin cancers, especially in advanced or recurrent cases, are essential to ensure tumor-free margins and minimize the risk of recurrence. However, these interventions often result in extensive skin defects that affect functional and aesthetic structures such as the face, hands and scalp. The removal of large areas of tissue can significantly compromise patients' quality of life, leading to not only medical, but also psychological and social challenges (Karia et al., 2013).

These impacts highlight the need for appropriate reconstructive approaches to restore both functionality and appearance.

The management of complex post-resection skin defects requires advanced reconstruction techniques that go beyond simple skin grafts. Local and regional flaps, such as advancement, transposition or rotation flaps, are often used to cover minor or moderate defects. However, in cases of extensive resections or areas with irradiated tissues, microsurgical reconstruction with vascularized free flaps is indispensable. These flaps offer

advantages in terms of blood supply, integration with adjacent tissues and the potential to cover large volumes, although they are technically challenging procedures and depend on specialized infrastructure (Demirkan et al., 2019).

In addition to traditional techniques, technological advances have been incorporated into clinical practice, expanding the possibilities for reconstruction. The use of dermal substitutes, biomaterials and 3D printing has allowed for better preoperative planning and superior aesthetic results. These methods are particularly useful in defects located in visible areas, such as the face and neck, where restoring symmetry and functionality is essential. However, the high costs associated with these technologies still represent an obstacle to their widespread implementation in public health systems (Lonie et al., 2016).

Surgical treatment for skin cancer often requires reconstructive interventions to repair skin defects resulting from resections. One of the most common approaches is the use of skin grafts, which involve the transfer of partial or total layers of skin from a donor area to cover the defect. Grafts are indicated for areas where the recipient bed is healthy and well vascularized, and are widely used due to their simplicity and effectiveness in small to moderate defects. Despite their usefulness, they have aesthetic limitations, such as differences in texture and pigmentation, and a greater risk of failure in areas with compromised vascularization (Burd et al., 2010).

Local and regional flaps are fundamental techniques for reconstructing more complex defects. These approaches use tissue adjacent to the defect, maintaining its native vascularization, which increases the flap's chance of survival. Advancement, rotation and transposition flaps are often used in areas such as the face, where the functional and aesthetic outcome is critical. In larger defects, regional flaps, such as the pectoralis major muscle flap or the anterolateral thigh flap, offer a robust alternative, especially in patients with deep or irradiated defects (Mathes & Nahai, 2017).

In cases of extensive defects or in areas with compromised tissue, microsurgical techniques are indispensable. These procedures involve the transfer of vascularized free flaps, such as the rectus abdominis flap or the radial flap, connecting the vessels of the transplanted tissue to the local vessels through microanastomoses. These techniques allow the reconstruction of large volumes of tissue with excellent blood supply, providing better integration and healing. However, they are technically challenging procedures that require specialized staff and advanced equipment, as well as longer surgical times and high costs (Demirkan et al., 2019).

According to Mathes & Nahai, (2017), microanastomoses (FIGURE 1), are advanced surgical techniques used to connect small blood or lymphatic vessels, usually with a diameter of less than 3 mm. These connections are made under a surgical microscope, using specialized microsurgical instruments and extremely fine sutures.

They are essential in various areas of surgery, such as: Reconstructive surgery: Reconnection of blood vessels in tissue transplants (free flaps); Reconstruction of amputated limbs; Organ transplantation: Connecting blood vessels during transplants of small organs such as the kidney or liver; Treatment of lymphedema: Connections between lymphatic vessels and veins to relieve fluid accumulation; Plastic and aesthetic surgery: Use in procedures such as capillary transplantation with vascularized flaps; Neurosurgery: Repair of intracranial vessels in cases of aneurysms or trauma. The high precision required reduces the risk of thrombosis (clot formation) and guarantees the viability of the reconnected tissue, making it essential for re-establishing blood or lymph flow in operated areas.

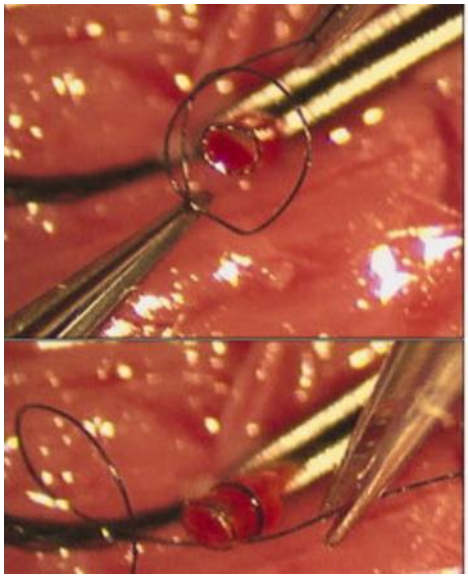


Figure 1. Surgical techniques for vascular microanastomosis: cuff method. The sutureless cuff technique is an elegant and simple method for performing anastomoses of extremely small vessels (diameter 0.1-0.2 mm), as shown for the heterotopic hind limb transplant model. Source: Brandacher, Gerald et al.2012.

The surgical techniques used to reconstruct skin defects after skin cancer resection have different success rates in covering the defect. Skin grafts (FIGURES 2 and 3), for example, are highly effective in small and moderate defects in well-vascularized areas, with integration rates of over

85% in healthy beds. However, more advanced techniques, such as local and regional flaps, show greater success in larger or more complex defects, due to the maintenance of native vascularization. Free microsurgical flaps, on the other hand, have survival rates above 90%, especially in extensive or irradiated defects, although they require surgical expertise and a longer operative time (Demirkan et al., 2019; Burd et al., 2010).

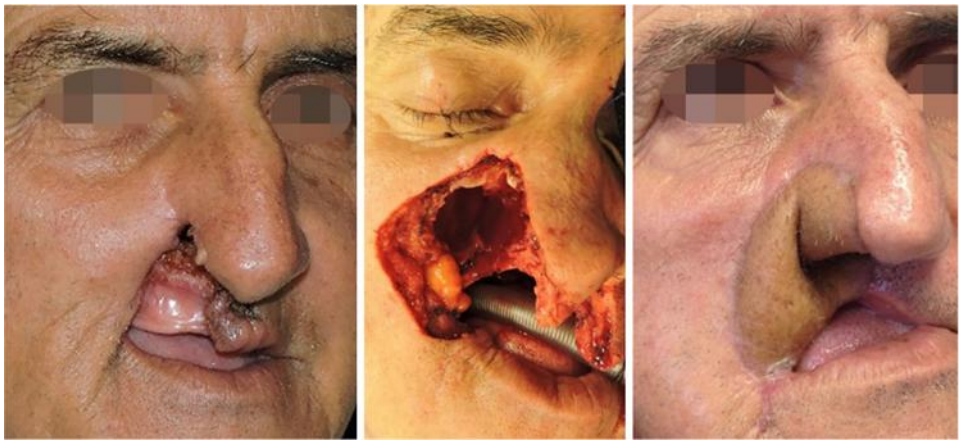


Figure 2. Microsurgical flaps, recipient vessels and surgery and hospitalization time. Source: (Nepomuceno, et al, 2016)

Figure 3. Radial antebrachial flap for facial reconstruction. Source: (Nepomuceno, et al, 2016).

Complications vary according to the technique used and the patient's condition. Skin grafts have an increased risk of failure in poorly vascularized beds, while local flaps can present partial necrosis due to inadequate tension or vascular compromise. Microsurgical flaps, although technically advanced, are not without complications, including venous or arterial thrombosis at the anastomoses, as well as infections in immunosuppressed patients. In general, complication rates are higher in previously irradiated areas or in patients with significant comorbidities (Mathes & Nahai, 1997; Karia et al., 2013).

Aesthetic and functional results are another crucial aspect when choosing a surgical technique. Skin grafts can lead to discrepancies in texture and color, negatively impacting the aesthetic result, especially in visible areas such as the face. Local and regional flaps provide better aesthetic results by utilizing adjacent tissues, while microsurgical flaps offer a superior solution for extensive defects, restoring volumes and anatomical contours in a more natural way. However, the technical complexity and costs associated with microsurgical techniques limit their applicability in certain contexts (Lonie et al., 2016; Rogers et al., 2015).

Local flaps are widely used in the reconstruction of skin defects after skin cancer resection due to their technical simplicity and efficiency in moderate-sized defects. These techniques use tissue adjacent to the defect, maintaining its native vascularization, which reduces the risk of complications such as necrosis. They are particularly effective in areas such as the face, where preserving the texture and color of the tissue is essential for the aesthetic result. However, their applicability is limited in extensive defects or areas with significant tension, where tissue stretching can compromise the viability of the flap (Mathes & Nahai, 1997; Demirkan et al., 2019).

On the other hand, free flaps, which involve the transfer of distant tissues with microsurgical reconnection of the vessels, offer greater versatility in covering complex and extensive defects. These techniques are essential in areas where the local tissue is unsuitable due to lack of elasticity or previous damage, such as radiation. In addition, free flaps allow for three-dimensional reconstructions, restoring both volume and functionality in deep defects. However, their greater technical complexity requires specialized equipment and trained surgeons, which can increase the cost and operating time, as well as raising the risk of complications related to vascular anastomosis, such as thrombosis (Demirkan et al., 2019; Lonie et al., 2016).

Despite the differences in simplicity and versatility, both techniques play complementary roles in the management of skin defects. While local flaps are preferred in less complex cases due to their rapid execution and effectiveness, free flaps are the ideal choice for larger defects or in anatomically challenging locations. The selection of the technique depends not only on the size and location of the defect, but also on the clinical conditions of the patient and the experience of the surgical team (Burd et al., 2010; Rogers et al., 2015).

The surgical techniques used to reconstruct skin defects after skin cancer resections offer specific advantages and limitations, depending on the approach used. Local flaps stand out for their technical simplicity, rapid execution and good integration with the recipient tissue, especially in small or moderate defects. Their main advantage is the maintenance of texture and coloration similar to the original tissue, and they are often chosen for areas of high visibility, such as the face. However, these flaps have limitations in larger defects or in areas with insufficient elasticity, which can lead to excessive tension and partial necrosis (Mathes & Nahai, 1997; Burd et al., 2010).

Skin grafts, a widely used alternative, are particularly useful in defects with well-vascularized beds and less stringent aesthetic requirements. They are a simple and economical option for covering large areas, but have aesthetic disadvantages, such as differences in texture and color, as well as a greater risk of failure in irradiated beds or those with compromised vascular supply. In addition, the need for a donor area increases patient discomfort and potentially complicates the postoperative period (Burd et al., 2010; Rogers et al., 2015).

On the other hand, free flaps, which use microsurgical techniques, offer the greatest versatility for reconstructing extensive and complex defects. They allow the transfer of large volumes of well-vascularized tissue, which is essential for covering areas with significant functional impairment or irradiated scars. Despite this, their technical complexity, longer operative time and associated costs limit their application in centers without adequate infrastructure. In addition, complications such as vascular anastomosis failures, including arterial or venous thrombosis, can negatively impact the outcome (Demirkan et al., 2019; Lonie et al., 2016).

FIGURE 4 shows a possible flap donor area.

Figure 4. Donor area of the anterolateral thigh flap. Source: (Nepomuceno, et al, 2016).

In a critical analysis, the advantages and limitations of each technique make the selection dependent on the clinical context and the patient's needs. Local flaps are preferable for less complex cases due to their simplicity and low cost, while free flaps are indispensable in larger or anatomically challenging defects. Surgical decisions must balance functionality, aesthetics, risks and available resources, ensuring the best outcome for the patient (Mathes & Nahai, 1997; Rogers et al., 2015).

In turn, 3D printing has emerged as an essential tool in plastic surgery due to its ability to create accurate anatomical models for surgical simulation. These models reproduce the patient's anatomical details with high fidelity, allowing surgeons to plan procedures more accurately, which results in reduced operative time and improved clinical results. According to a study published by Chae et al. (2020), the use of 3D printing in surgical planning improves the predictability of results and reduces post-operative complications (Chae et al., 2020).

In the field of medical training, 3D printed models are used to simulate complex procedures, allowing specific techniques to be practiced before being performed on real patients. These models offer similar strength and texture to human tissue, helping to train surgical teams. A study by He et al. (2018) showed that medical students who used 3D models performed significantly better in surgical skills tests compared to traditional teaching methods (He et al., 2018).

In addition, the technology makes it possible to manufacture customized prostheses and implants, optimizing the integration of materials into the patient's body and providing better aesthetic and functional results. According to a systematic review by Mota et al. (2021), customization by

3D printing has proven effective in facial and craniomaxillofacial reconstruction surgeries, increasing patient satisfaction and reducing the need for subsequent adjustments (Mota et al., 2021).

However, challenges still need to be addressed, such as the high costs of equipment and materials, as well as the need for trained professionals to operate the technology. In addition, the accuracy of the models and the biocompatibility of the materials used are areas that require constant improvement. As highlighted by Wu et al. (2019), the implementation of 3D printing requires an interdisciplinary approach to overcome technical and financial barriers (Wu et al., 2019).

3D printing represents a revolution in the planning and execution of plastic surgery, with benefits ranging from improved training for professionals to increased surgical precision. Although there are challenges, the continuous evolution of this technology promises to further expand its impact on clinical practice, as evidenced by several studies in the field (Yang et al., 2022).

## CONCLUSION

Surgical approaches to complex skin defects in patients with a history of skin cancer represent a significant challenge, requiring a balance between complete tumor removal, functional preservation and achieving satisfactory aesthetic results. The choice of reconstructive method must be individualized, taking into account factors such as the location and extent of the defect, the histological type of cancer, the patient's clinical conditions and aesthetic expectations.

Techniques such as skin grafts, local and regional flaps, and microsurgical reconstructions have proven effective in anatomical and functional restoration, and are often combined to optimize results. In addition, advances such as the use of 3D printing for surgical planning and biocompatible materials are emerging as promising tools in the management of these cases.

It is essential that the reconstructive approach is multidisciplinary, involving dermatologists, oncologists, plastic surgeons and other specialists. Strict post-operative follow-up is also essential to monitor recurrences, treat complications and ensure the patient's functional and aesthetic recovery.

The continuous evolution of surgical techniques and auxiliary technologies promises to expand the therapeutic options available, providing better results for patients with complex skin defects resulting from skin cancer treatment.

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