Innovations in skin cancer treatment: From traditional approaches to targeted therapies.

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Introduction

Skin cancer, the most common form of cancer worldwide, is primarily categorized into basal cell carcinoma (BCC), squamous cell carcinoma (SCC), and melanoma. With rising global incidence, the demand for effective treatments has become paramount. This article traces the evolution of skin cancer therapies, from traditional surgical methods to cutting-edge targeted therapies, showcasing innovations that are transforming patient outcomes [1].

Historically, surgery has been the cornerstone of skin cancer treatment. Excisional surgery, in which the tumor and a margin of surrounding healthy tissue are removed, has proven effective for most BCC and SCC cases. Mohs micrographic surgery, introduced in the 1930s, is a more refined technique that enables the precise removal of cancerous tissue while sparing as much healthy skin as possible. Despite its success in early-stage cases, surgery has limitations, particularly in advanced or metastatic disease [2].

Radiation therapy has been employed as a non-invasive treatment, particularly for patients ineligible for surgery. It works by targeting cancer cells with ionizing radiation, which damages their DNA and hinders their ability to replicate. While effective for certain cases, radiation therapy can cause side effects such as skin irritation, fatigue, and in rare cases, secondary cancers. Its role has become more supplementary, often used in combination with surgery or chemotherapy [3].

For more advanced or metastatic skin cancers, traditional chemotherapy has been a common approach. Drugs like dacarbazine and cisplatin are often used to kill rapidly dividing cancer cells. However, chemotherapy is non-specific, meaning it also affects healthy cells, leading to significant side effects such as nausea, fatigue, and immunosuppression. In recent years, its use in skin cancer has declined as more targeted treatments have emerged [4].

One of the most revolutionary innovations in skin cancer treatment is immunotherapy, which harnesses the body's immune system to fight cancer. Checkpoint inhibitors like pembrolizumab and nivolumab, which target proteins such as PD-1, have shown remarkable success in treating metastatic melanoma. These drugs essentially "release the brakes" on the immune system, allowing it to recognize and destroy cancer cells. Immunotherapy has significantly improved survival rates for melanoma patients [5].

Targeted therapy represents another breakthrough in skin cancer treatment. Unlike chemotherapy, which attacks all fast-growing cells, targeted therapies are designed to interfere with specific molecular pathways critical for cancer cell survival. For example, BRAF inhibitors (e.g., vemurafenib) have been developed for patients with BRAF-mutant melanoma. Similarly, MEK inhibitors target another pathway crucial in melanoma growth. These therapies have prolonged survival in patients with specific genetic mutations [6].

Photodynamic therapy (PDT) offers a less invasive option, particularly for non-melanoma skin cancers. PDT involves applying a photosensitizing agent to the affected area, followed by exposure to light, which activates the agent and destroys cancerous cells. The therapy is minimally invasive and can be performed on an outpatient basis, making it an appealing option for superficial BCC and SCC cases. However, it remains limited in treating deeper or more aggressive tumors [7].

The combination of therapies has become a common strategy to enhance treatment efficacy. For instance, combining BRAF inhibitors with MEK inhibitors has demonstrated superior outcomes compared to monotherapy for advanced melanoma. Similarly, immunotherapy may be combined with radiation or chemotherapy to create a synergistic effect, maximizing the immune response while directly targeting cancer cells. This multi-modal approach has emerged as a way to address resistance mechanisms that often arise during single-agent treatments [8].

Advances in genomics have paved the way for personalized medicine, a treatment approach tailored to the individual's genetic makeup. Gene therapy, though still in experimental stages, holds potential for skin cancer treatment by directly altering cancer-related genes to inhibit tumor growth. Techniques like CRISPR-Cas9 gene editing could one day offer precise corrections of genetic mutations in skin cancer patients. This field remains highly promising as research into cancer genomics accelerates [9].

Nanotechnology is another innovative approach making strides in oncology, including skin cancer. Nanoparticles can be engineered to deliver drugs directly to cancer cells, enhancing treatment specificity and minimizing damage to healthy tissue. Nanocarriers such as liposomes and dendrimers can encapsulate therapeutic agents, improving their solubility, stability, and absorption. These advances are paving the way

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for more effective and targeted treatment delivery systems in the future [10].

Conclusion

The landscape of skin cancer treatment has undergone a remarkable transformation, moving from broad, non-specific therapies to highly targeted, personalized approaches. Innovations such as immunotherapy, targeted therapies, and AI-driven diagnostics have significantly improved patient outcomes, especially in advanced melanoma cases. While challenges persist, the future of skin cancer treatment is promising, with ongoing research driving the development of even more precise, effective, and accessible treatments.

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