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Modern Concepts of Skin Stem Cells And Their Role In Epidermal Regeneration Covering The Latest Research On Stem Cell Niches, Their Activation Mechanisms And Applications In Tissue Engineering And Skin Transplantation

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Abstract: Skin stem cells play a key role in maintaining homeostasis and regeneration of the epidermis, ensuring continuous renewal of the skin and restoration of damaged areas. The article discusses modern concepts of the morphological and functional features of skin stem cell niches, as well as the mechanisms of their activation and differentiation. The latest research aimed at using these cells in tissue engineering and transplantation technologies, which open up new prospects for the treatment of skin diseases and injuries, is highlighted. Particular attention is paid to biomedical approaches to managing regenerative processes using stem cells to improve the effectiveness of therapy and create artificial skin substitutes.

Keywords: Skin stem cells, epidermis, regeneration, stem cell niches, cell activation, tissue engineering, skin transplantation, differentiation, skin restoration.

Introduction: The skin is the largest organ of the human body and performs many vital functions, including barrier protection from external influences, participation in the immune response, temperature regulation and perception of sensory signals. The main layer of the skin responsible for renewal and restoration is the epidermis - a multi-layered epithelium that is constantly renewed throughout life due to the activity of stem cells.

Skin stem cells are a specialized population pool of cells with a high capacity for self-reproduction and multifaceted differentiation. They provide regeneration and homeostasis maintenance of the epidermis, playing a key role in wound healing and restoration of damaged skin areas. These cells are localized in various specialized microenvironments - niches, such as the basal layer of the epidermis, hair follicles and sebaceous glands. The niche microenvironment maintains the stem properties of cells and regulates their proliferation and differentiation through complex signaling pathways and interactions with surrounding cells and the extracellular matrix.

Modern methods of molecular biology, cell visualization and genetic analysis allow us to better understand the mechanisms of activation of skin stem cells in response to damage and their role in dynamic regeneration processes. Disturbances in the functioning of these cells are associated with various pathologies, including chronic wounds, psoriasis, and skin cancer.

In addition, the study of skin stem cells is important for the development of tissue engineering, a promising field aimed at creating bioengineered skin substitutes and effective transplantation methods. The use of stem cells in regenerative medicine opens new horizons for the treatment of burns, wounds, as well as genetic and autoimmune skin diseases, improving the quality of life of patients.

This article will review current understanding of the morphology and functional characteristics of skin stem cells, their niches, activation mechanisms, and role in

epidermal regeneration. Particular attention will be paid to the latest advances in tissue engineering and clinical application of these cells in transplantology.

Purpose of the study

To study modern concepts of skin stem cells, their niches and activation mechanisms, and to assess the prospects for their use in epidermal regeneration and tissue engineering.

Materials and methods

The PubMed , Scopus and Web databases were used to search for literature. of Science with filtering of articles published in the last 10 years.

The analysis included the results of molecular biological, histological and experimental studies on models in in vitro and in vivo , which reveal the features of the morphology of skin stem cells and their functional activity. Particular attention was paid to works describing methods of culturing stem cells, tissue engineering models and clinical studies on the use of cell technologies in the treatment of skin lesions.

When describing the mechanisms of stem cell activation, data on signaling pathways that influence cell proliferation and differentiation under physiological conditions and tissue damage were taken into account.

RESULTS AND DISCUSSION

Modern research confirms that skin stem cells are represented by several populations located in different niches of the epidermis, hair follicles and sebaceous glands. Each of these niches has unique microenvironments that support the stem properties of the cells and regulate their activation in response to physiological needs or skin damage.

The cells of the basal layer of the epidermis provide constant renewal of the superficial layer of the skin due to the ability to self-reproduce and differentiate. Hair follicles contain a separate group of stem cells that participate not only in hair growth, but also in the reparation of the epidermis in case of damage. Pericytic and mesenchymal components of niches play an important role in the regulation of the cell cycle and immune response.

Skin stem cell activation is mediated by a complex of signaling pathways, including Wnt /β- catenin , Notch , Hedgehog , and TGF-β, which ensure precise coordination of proliferation and differentiation. Disruptions in these pathways are associated with pathological processes, including delayed wound healing and cancer development.

Significant advances have been made in tissue engineering through the development of methods for culturing and differentiating skin stem cells, allowing the creation of artificial skin substitutes that are close in structure and function to natural skin. Cellular technologies, including the use of mesenchymal stem cells and induced pluripotent stem cells (iPSCs), have shown high efficiency in regenerating damaged tissue and reducing inflammatory responses.

Clinical studies show promise for the use of stem cells in the treatment of burns, chronic wounds and dermatological diseases, but challenges remain related to the control of differentiation, immunogenicity and graft integration.

Thus, further understanding of the biology of skin stem cells and their niches, as well as the development of safe and effective cell therapies, are critical for progress in regenerative medicine and improving the quality of life of patients with skin pathologies.

CONCLUSION

Skin stem cells play a key role in maintaining homeostasis and regeneration of the epidermis, ensuring continuous renewal of the skin and recovery from damage. Modern research has significantly expanded our understanding of stem cell morphology, the characteristics of their niches and activation mechanisms, which opens up new opportunities for the development of effective methods of tissue engineering and skin transplantation. The use of stem cells in regenerative medicine contributes to the creation of innovative approaches to the treatment of burns, chronic wounds and other skin pathologies, improving the quality of life of patients. Further study of these cells and their microenvironments is important for improving clinical technologies and developing personalized therapy.

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