

3D Bioprinting: Bioinks for human skin fabrication

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Abstract

3D bioprinting is a cutting-edge additive manufacturing technology that combines 3D printing and biofabrication to create complex biological structures such as tissues and organs. This process utilizes bioinks to print viable biomedical components. Among its critical applications, 3D bioprinting of human skin plays a significant role in regenerative medicine, offering potential solutions for wound healing, skin grafting, and pharmaceutical testing, thus reducing the need for clinical trials on human subjects.

The bioprinting process involves three primary techniques: microvalve-based bioprinting, laser-assisted bioprinting, and extrusion-based bioprinting. These techniques differ in precision, cell viability, and printing efficiency. Temperature and pressure regulation are crucial throughout the process, as bioinks contain sensitive biological molecules and living cells that require optimal environmental conditions to remain viable. Hydrogels serve as the primary medium for bioinks due to their ability to retain water and support cellular functions. The solidification or gelation of bioinks after printing is achieved through various methods, ensuring the structural integrity of the printed constructs.

The human skin, the body's largest organ, consists of three layers: the epidermis, dermis, and subcutaneous tissue, each fulfilling essential physiological roles. Successful skin bioprinting relies on careful cell selection, primarily keratinocytes for the epidermis and fibro-blasts for the dermis, to replicate native skin structures. The composition of bioinks is meticulously formulated to meet specific mechanical, rheological, and biological requirements, ensuring proper printability, immunological compatibility, and bio-mimicry of skin tissue.

As 3D bioprinting technology advances, comparative analyses of different bioink formulations, printing methods, and material properties contribute to the refinement of bioprinted skin constructs. Research efforts continue to optimize structural integrity, cell viability, and functional integration, bringing bioprinted skin closer to clinical and commercial applications. This paper presents the fundamental principles, materials, and methodologies involved in 3D bioprinting of skin, highlighting its potential in biomedical engineering and regenerative medicine. Additionally, it aims to identify the most efficient bioprinting method and the optimal bioink composition that ensures

the highest cell survival rate, both immediately after the printing process and throughout the incubation period.

Keywords: 3D bioprinting, bioink, human skin bioprinting