To What Extent Can Tissue Engineering and 3D Bioprinting Be Used to Create Functional and Vascularized Human Organs?

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***Abstract*—Organ transplantation, a cornerstone of modern medicine for more than 60 years, faces significant challenges due to limited organ donor availability, organ rejection, and immunosuppression risks. The increasing prevalence of diseases and longer life expectancy have intensified the demand for transplantation, leading to longer waiting lists and increased mortality rates. To address these issues, recent advances in tissue engineering and 3D bioprinting offer promising alternatives. While tissue engineering builds functional tissues from biomaterials and stem cells, 3D bioprinting organises cells layer by layer to create living organs. 3D bioprinting techniques are categorised as extrusion-based, inkjet, and laser-assisted methods. Extrusion-based bioprinting, the most common, uses pneumatic or mechanical systems to dispense bio-ink but struggles with high-viscosity bio-inks and cell viability. Inkjet bioprinting, which deposits bio-inks in droplets, achieves high cell viability but faces droplet consistency and heat sensitivity challenges. Laser-assisted bioprinting eliminates nozzle-related issues and provides high resolution but can damage bio-ink components due to shear forces. Despite these limitations, 3D bioprinting has significant potential to advance organ transplantation by developing functional human organs, thus addressing the critical organ shortage.**

Since the first successful human organ transplant over 60 years ago, organ transplantation has evolved into an established and widely practiced medical discipline and is firmly integrated into everyday medicine. However, the efficacy of organ transplantation is constrained by the limited availability of organ donors and the risks of rejection and immunosuppression. This challenge, along with the rising prevalence of disease and increased human longevity, has led to an exponential surge in the number of patients on transplant waiting lists and their subsequent elevated mortality rates. To meet this rising demand, scientists

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