Integration of three-dimensional multicolor holography with microfluidic three-dimensional biofilm-on-a-chip technology for advancing the treatment of diabetic foot ulcers: An innovation in phage therapy

Sir,

The treatment of diabetic foot ulcers (DFUs) remains a significant challenge in healthcare due to the persistent and complex development of bacterial biofilms. These biofilms resist the effect of conventional antibiotics. Phage therapy has been introduced as an alternative method, which helps in bacterial elimination with minimal side effects. However, one of the primary problems in advancing phage therapy is the lack of effective models to study biofilm dynamics and optimize treatment strategies. To overcome all these problems and challenges, the innovative approach of integrating three-dimensional (3D) multicolor holography technology with microfluidic 3D biofilm-on-a-chip technology can advance biofilm research and enhance phage therapy for DFUs. Traditional and old biofilm studies rely on static two-dimensional culture models, which are not able to replicate the complexity of biofilms in chronic wounds. Microfluidic 3D biofilm-on-a-chip technology provides a dynamic, physiologically useful platform that replicates the wound microenvironment, allowing real-time monitoring of biofilm formation, maturation, and response to phage treatment. This microfluidic system enables controlled nutrient flow, simulating in vivo conditions more accurately, which is not possible in conventional methods [Table 1].[1] The addition of 3D multicolor holography technology with microfluidic 3D biofilm-on-a-chip technology further enhances this approach by providing high resolution, real-time imaging of biofilm structure, bacterial viability, and phage interactions at the cellular level. This innovative approach allows for a 3D color coded visualization of biofilm components, distinguishing live and dead bacteria, extracellular polymeric substances, and phage penetration efficiency. Such detailed imaging enables researchers to clinically study phage efficacy more accurately and optimize the treatment protocols for better clinical outcomes [Table 1].[2]

Table 1: Advantages of integrating three-dimensional multicolor holography with microfluidic three-dimensional biofilm-on-a-chip in phage therapy for clinical studies[1-4]

Innovation	Advantages
Microfluidic 3D biofilm-on-a-chip technique[1]	Mimics and replicate real wound environment for accurate biofilm modeling[1]
3D multicolor holography[3]	Provides real-time, high-resolution imaging of biofilm structure[3]
Phage-biofilm interaction analysis[4]	Improve understanding of phage penetration and efficacy[4]
Personalized phage therapy development[4]	Personalized treatment strategies based on patient-specific biofilms[4]
Reduced antibiotic dependence[2]	Promotes nonantibiotic treatment for antibiotic-resistant infections[2]

3D=Three-dimensional

Integrating this 3D multicolor holography with microfluidic 3D biofilm-on-a-chip technology is useful for phage therapy, which can be customized, personalized, and more effective according to individual patients need. This innovative approach has the ability to identify optimal phage combinations, dosing strategies, and treatment durations, which will significantly improve therapeutic outcomes for DFU patients. In addition, the ability to visualize biofilm physiology in real time can be beneficial for developing effective phage combination. These phage combinations can be useful as a target-specific bacterial strains with greater precision.[2] Despite these advancements, challenges such as the high cost of implementing these technologies and the need for specialized training must be addressed. Collaborative efforts between researchers, clinicians, and biomedical engineers are crucial to refining and making this technology more accessible for widespread use in clinical and research settings.[5]

In conclusion, combining and integrating 3D multicolor holography with microfluidic 3D biofilm-on-a-chip technique gives a revolutionary approach to studying biofilm-associated infections and optimizing phage therapy for DFUs. This innovation has the potential to transform chronic wound management, reduce antibiotic resistance, and improve patient outcomes. As per educational point of view, this innovative approach will improve the understanding of biofilm structure, treatment of strategies, and clinical studies.

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Conflicts of interest
There are no conflicts of interest.

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