INNERVATED AND IMMUNE-COMPETENT TISSUE-ON-CHIP SYSTEMS FOR PRECISION MEDICINE

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Abstract: Personalized and precision medicine are driving a shift toward patient-specific diagnostic and therapeutic strategies that account for individual molecular, cellular, and physiological variability. To support this transformation, the combination of advanced in vitro and in silico models are needed to replicate human tissue complexity and predict treatment response with high fidelity. Tissue- and organ-on-chip (ToC/OoC) systems represent a powerful platform in this context. These devices recreate dynamic, controllable microenvironments where engineered human tissues can exhibit native-like structure and function. When generated from patient-derived or induced pluripotent stem cells, ToC systems enable personalized modeling of disease and therapeutic outcomes, supporting preclinical testing and drug discovery. Recent developments from our group focus on innervated and immune-competent tissue-on-chip platforms, which integrate neuronal and immune components with muscle, skin, or vascular tissues to reproduce essential cross-talk mechanisms. These systems allow the study of neuro-immune regulation, inflammation, regeneration, and disease progression in a physiologically relevant context. Coupled with computational and multi-omics modeling approaches, such platforms offer new opportunities for predictive analysis and mechanistic insight. Together, they represent a promising strategy to accelerate precision medicine and reduce reliance on animal models, paving the way toward ethically sound, patient-tailored therapeutic innovation.

Key words: *tissue on chip, neuro-immune regulation, precision medicine*