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NOVEL APPROACH IN DESIGNING MICROFLUIDIC DEVICES BASED ON FINITE ELEMENT AND TOPOLOGICAL OPTIMISATION METHODS

Nevena Milivojević[(1)], Dalibor Nikolić[(1)], Marko Živanović[(1)], Nenad Filipović[(2)]
[(1)]Institute of Information Technologies, University of Kragujevac, Serbia
[(2)]Faculty of Engineering, University of Kragujevac, Serbia
nevena_milivojevic@live.com, markovac85@kg.ac.rs, zivanovicmkg@gmail.com, fica@kg.ac.rs

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Summary: Preclinical experiments require reliable, physiologically relevant systems that can reproduce complex human physiology. Further technological advances are urgently needed to gain a better understanding of the important biological processes, like circulation networks for the discovery and screening of new drugs. Traditional 2D and 3D in vitro approaches are widely used, but they cannot reproduce the complexity of native scenarios. These models are generally static and lack vasculature and shear stress forces, typically failing to reproduce the rheological properties of the physiological processes. Similarly, in vivo animal models rarely mimic human conditions, the results may not be fully representative of those obtained in humans, and they are ethically questionable. A new paradigm has emerged in preclinical modeling aimed at overcoming the limitations of previous methods. A combination of advanced tissue engineering, cell biology, and nanotechnology has developed a state-of-the-art microfluidic model with an unprecedented ability to reproduce the natural habitat of cells and tissues in microfluidic devices. The main issue with those devices is a consistent fluid distribution trues them. The construction of chambers and channels has a huge impact on the distribution of nutrients and drugs in each part of the device (to each testing tissue on a chip). This paper describes a novel approach in designing chip devices by using the finite element method (FEM) and topological optimization (TO) method for in silico testing and optimizing the shape of the features (chambers and channels). This approach minimizes mistakes in features design and provides the full potential of novel microfluidic devices.

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