In silico design of additively manufactured scaffolds for skeletal tissue engineering

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ABSTRACT

One of the major challenges in tissue engineering and an essential step towards successful clinical applications is the translation of biological knowledge on complex cell and tissue behavior into predictive and robust engineering processes. Computational modelling can contribute to this, among others because it allows to study the biological complexity in a more quantitative way. Computational tools can help in quantifying and optimizing micro-environmental signals to which cells and tissues are exposed and in understanding and predicting the biological response under different conditions.

A wide variety of model systems has been presented in the context of tissue engineering ranging from empirical models (data-driven) over gene network models to mechanistic models (hypothesis-based), targeting processes at the intracellular over the cellular up to the tissue level. Each model system has its own benefits and limitations which delineate the context in which it can be used. Whereas mechanistic models are used as in silico tools to design new therapeutic strategies and experiments, empirical models are used to identify, in large data sets, those in vitro parameters (biological, biomaterial, environmental) that are critical for the in vivo outcome.

In this talk I will show a number of examples of these models, all related to the optimization of scaffold design in the context of skeletal tissue engineering. In order to optimize (additively manufactured) bioceramics-based biomaterials, we have developed models simulating the degradation of the biomaterials upon in vivo implantation, as well as the influence the degradation products have on the local biology [1]. Extensive screening experiments have guided the model formation. This model technology is currently also being applied to design degradable metal scaffolds for similar biological indications [2]. Other in silico models are able to predict the optimal scaffold geometry and quantify the created microenvironment for cells seeded onto the scaffold during perfusion bioreactor culture [3] or try to identify the local mechanical forces put on cells inside hydrogel containing bioinks during 3D bioprinting

The talk will end with an outlook on the different actions that need to be taken when bringing in silico models from the bench to the bed side.

REFERENCES

[1] Carlier A, Chai YC, Moesen M, Theys T, Schrooten J, Van Oosterwyck H, Geris L., "Designing optimal calcium phosphate scaffold-cell combinations using an integrative model-based approach." *Acta Biomater.* **7**(10):3573-85 (2011).

[2] Bajger P, Ashbourn JMA, Manhas V, Guyot Y, Lietaert K, Geris L., "Mathematical modelling of the degradation behaviour of biodegradable metals.", *Biomech Model Mechanobiol.* **16**(1):227-238 (2017).

[3] Guyot Y, Papantoniou I, Luyten FP, Geris L., "Coupling curvature-dependent and shear stress-stimulated neotissue growth in dynamic bioreactor cultures: a 3D computational model of a complete scaffold.", *Biomech Model Mechanobiol.* **15**(1):169-80 (2016).