TOPOLOGY OPTIMIZATION OF SCAFFOLDS FOR BONE TISSUE ENGINEERING

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Scaffolds for Bone Tissue Engineering should be able to provide temporary mechanical support and to promote cell proliferation and differentiation, as well as, oxygen and nutrient diffusion. Topology optimization is a suitable approach for bone scaffold design since it allows us to obtain well controlled microstructures that satisfy such requirements. In this lecture recent developments on scaffold design will be presented [1]. The scaffold is assumed to be a periodic porous material obtained by the repetition of a representative volume element (unit cell). The optimization problem is defined in order to obtain the optimal topology of the unit cell that satisfied the objective of maximum permeability (for cell proliferation and nutrient diffusion) and stiffness (to provide mechanical support). The elastic properties and permeability of the porous media are determined using asymptotic homogenization. There are several possibilities to define the optimization problem. Here a multi-criteria formulation is presented to optimize for permeability and stiffness concurrently as well as a formulation to optimize for one objective and consider the other as a constraint. A multiscale approach is also discussed. This methodology has demonstrated its capability to provide solutions of microstructures able to promote diffusion without compromising the mechanical properties. An advantage of the formulation proposed is to obtain tailored scaffolds when the considered strain field mimics the strain field on bone site where the bone substitute will be applied. Although those structures can be obtain using a suitable rapid prototyping manufacturing process, the best technique to apply as well as the material to use are still open issues. Thus, the assessment of the designed scaffold properties after fabrication as well as on its performance in vivo will also be discussed.

References

[1] M Dias, J Guedes, C Flanagan, S Hollister, PR Fernandes, Optimization of Scaffolds Design for Bone Tissue Engineering: Computational and Experimental Study, *Med Eng Phys*, 36:448-457, 2014