The Use of Triple Periodic Geometries for Scaffold Design in Tissue Engineering Applications
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Introduction
Tissue engineering represents a new, emerging interdisciplinary field involving combined efforts of biologists, engineers, material scientists and mathematicians towards the development of biological substitutes to restore, maintain, or improve tissue functions. Most strategies in tissue engineering have focussed on using biomaterials as scaffolds to direct specific cell types to organise into three-dimensional structures and perform differentiated functions. Scaffolds provide a temporary mechanical and vascular support for tissue regeneration while shaping the in-growth tissues. These scaffolds must be biocompatible, biodegradable, with appropriate porosity, pore structure and pore distribution and optimal vascularisation, with both surface and structural compatibility. Surface compatibility means a chemical, biological and physical suitability to the host tissue. Structural compatibility corresponds to an optimal adaptation to the mechanical behaviour of the host tissue.
Recent advances in the tissue engineering field are increasingly relying on modelling and simulation. The design of optimised scaffolds based on the fundamental knowledge of its microstructure is a relevant topic of research. This paper proposes the use of novel geometric structures based on the Triple Periodic Minimal Surfaces formulation. Geometries based on these surfaces enables the design of vary high surface-to-volume ratio structures with high porosity and mechanical/vascular properties.

Materials and Methods
With the use of a computational tool combining structural and computational fluid dynamic schemes, it is possible to predict and optimise both mechanical and vascular behaviour of scaffolds for soft and hard tissue applications, with different topological architectures and levels of porosity. This tool is particularly important to quantify the structural heterogeneity and scaffold mechanical properties with a designed microstructure subjected to either a single or a multiple load distribution.

Results
The results show that porosity decreases with the P-minimal thickness, decreasing also till a threshold value for the P-minimal surface radius. From this threshold value, porosity starts to increase. The elastic modulus increases with the P-minimal surface thickness and decreases by increasing the P-minimal surface radius. With this sort of design, it is possible to obtain two geometries with different levels of mechanical performance and the same level of porosity.

Discussion and Conclusions
Understanding the mechanical and transport properties of highly porous scaffolds from a knowledge of its microstructure is a problem of great interest in tissue engineering. In this paper, porous scaffolds are designed and its mechanical and vascular behaviour simulated using Triple Periodic geometries.