A numerical study on the ultrasound propagation in a 3D gyroid-shaped scaffold

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Bone substitutes can be used for pre-implant surgery in presence of volumetric bone defects. In this context, the ultrasound characterization of the bone substitute is a key issue. To this end we model the implant as a 3D porous structure and we study its ultrasonic behavior. In the framework of artificial bone substitutes, scaffolds are widely used. Their features must fulfill strict biomechanical specifications. The scaffold must match the elastic properties of the bone, in terms of stiffness, density and strength, but have the correct value of porosity to allow for cell migration and bone regeneration. In literature, several geometrical configurations have been tested: among them the gyroid-shaped scaffold turns out to be an excellent choice, thanks to its ability to reproduce the behavior and the porous structure of trabecular bone. This study is focused on the numerical simulations of wave propagation in a porous implant substitute. In particular, 3D finite-difference time-domain (FTDT) simulations were performed on a gyroid-shaped scaffold of 5 x 5 x 5 mm3 saturated with water. The choice of the gyroid microstructure allows for an easy manipulation of the geometry, in term of pore size, strut size and/or porosity. Indeed, in this study, we take into account variations of porosity and pore size. Moreover, ultrasound excitations ranging from 500 kHz to 5 MHz were tested in order to investigate the frequency-dependent behavior phase velocity. Furthermore, the dependence on frequency of reflection coefficient and attenuation will be shown, for different values of porosity and pore size.