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NUMERICAL EVALUATION OF THE PERMEABILITY OF IMPLANT WITH POROUS STRUCTURE

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Summary: In recent years, porous structures, like lattices, have attracted the attention of researchers and engineers to develop new biomedical applications based in bioinspired designs. It is intended to overcome some of drawbacks of conventional applications, mainly in relation to their high stiffness and strength and poor biological response at the interface with consequent loss of osteointegration [1-4]. Scaffolds and in particular, implants with an outer layer with a porous structure would permit the supply of oxygen and nutrients, promoting bone ingrowth [5,6], providing implant stability with long-term fixation and osseointegration. Porosity, pore size and interconnectivity are key important factors influencing the permeability of such structures. The advent of new additive manufacturing technologies, deleveraged the production of such complex designs, with metal alloys. For this study, it was considered three implant layers with different porous structures (Geo_1; Geo_2; Geo_3). Geo_1 is based in diamond cell, Geo_2 is based in cubic cell and Geo_3 is based is hexahedral cell. The implants had 10 mm height and an outer diameter of 6 mm. The porosity was, respectively, 68%, 61% and 80% and pore size were, respectively, 270 mm, 440 mm and 290 mm. Within this study, it was performed a computational fluid dynamic (CFD) evaluation, to determine the permeability of the three different geometries, according to different studies reported in literature [7-9]. The numerical simulation was carried out in ANSYS® Fluent version 2020 R2 and the permeability was determined by measuring the pressure drop between the model ends and the volumetric flow rate through the porous structure, according to Darcy's law and takin into account that the Reynolds number was kept close to 1. For this study, liquid water was considered as "fluid" with density of $1e^{-3}$ g/mm^3 and viscosity of $1.01e^{-9}$ MPa.s. For the boundary conditions were considered a vertical velocity inlet of 1 mm/s [7], an outlet pressure of zero Pa and a no slip wall condition. In order to reduce computational time and cost, only one quarter of the model was considered and a symmetry condition was imposed. For the simulation, only the fluid part was considered. It was obtained the permeability values of $1.38e^{-9}$ m^2, $5{,}77e^{-9}$ m^2 and $1{,}83e^{-9}$ m^2 for Geo_1, Geo_2 and Geo_3, respectively. The obtained results revealed the importance of the geometry of structures to improve the permeability. Another important aspect is the pore size, because independently of geometry the pore size plays an important role and helps to increase the permeability. All the presented results showed that the permeability of all porous structures were in the range of permeability of trabecular bone, according to [7,10].