Final Report

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2. Publishable project summary

Title: Drug delivering 3D printed scaffold strategy brings human body implants to the next level of personalization

Expected result of this project was a novel human body implants with a local drug delivery system offering patient-specific properties providing higher level of personalization. It was expected to introduce this advantageous technology that would change traditional human body implants to the new era of drug loaded personalized medical devices.
Microcapsules of various sizes and fractions have been made for gentamicin incorporation and its controlled release. The amount of gentamicin incorporated into the microcapsules was determined. Microcapsules were manufactured in a heterogeneous solid phase in water-in-oil-in-water and coated with hydroxyapatite nanoparticles. Quantitative studies of embedded drug gentamicin release from microstructural systems were performed. For quantitative determination of gentamicin liquid chromatography method was applied and developed. The antimicrobial activity of the formed gentamicin microcapsules was confirmed by in vitro studies with standard E. coli, S. aureus, Ps. aeruginosa strains.
The synthesis of submicronic α-tricalcium phosphate particles and their application in cement production were performed. In parallel, gentamicin release from formulated products was studied.
In vitro specimens materialization using additive fabrication (3D printing - DMLS technology) from biocompatible Ti-6Al-4V titanium alloy was developed. The trabecular structure specimens were adapted for successful insertion of calcium phosphate cements, as this was confirmed by the results of microcomputer tomography studies.
Sterilization of samples with ionizing gamma radiation was performed to determine the possible effect of the sterilization process on unprotected gentamicin, gentamycin embedded in polymeric microcapsules and pure calcium phosphate. An evaluation of the biological activity of the antibiotic after radiation sterilization was performed.
Gentamicin sulphate containing calcium phosphate bone cement (CPC) has been developed and used for modifications of porous structure of the 3D printed titanium implant. According to the obtained results, the amount of gentamicin sulphate released from CPC, clearly exceeded the MIC for microorganisms (MIC 0.5-8 μg/mL) during the period of 14 days and released GENTA concentration showed no risk of cytotoxicity (<30 μg/mL).
Additional studies of antimicrobial activity of implant test samples (pure CPC, CPC with gentamicin, CPC with unloaded microcapsules, CPC with gentamicin (5 mg) loaded microcapsules) with standard strains of S. aureus, E. coli and Ps. aeruginosa. Antimicrobial activity was determined for all bacterial strains when the antibiotic gentamicin was added to the test product, which confirmed the ability of the formulations to release sufficient amounts of the antibiotic.
Studies have been performed to evaluate the effect of implants on cellular metabolic activity and proliferation. The results of the toxicity study of the implants and their components suggest that the observed cellular toxicity is due to the presence of additional components used in formulation of the tested samples. It can be indicated that the observed effects on cell cultures were not so intense as to limit the application of the formulated microstructural systems to the controlled long-term release of gentamicin from the implant surface.