EFFECT OF TEXTURED SURFACE TOPOGRAPHY PARAMETERS ON CELLS PROLIFERATION AND TISSUE GROWTH IN THE MECHANICAL CIRCULATORY SUPPORT APPLICATION

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[ENGINEERING OF BIOMATERIALS 163 (2021) 47]

Introduction

Recently, the number of patients with heart failure has been increasing. The first step is to perform pharmacological treatment. However, when such treatment does not bring the expected effects, there may be a need to implement mechanical circulatory support (MCS). One possible solution is to use blood pumps such as Ventricular Assist Devices (VAD) [1]. These devices are nowadays widely used as an effective treatment for patients with advanced heart failure and are the only alternative to heart transplantation. Currently, the most commonly used VAD constructions in clinics are fully implantable. Therefore, it is very important to provide their high biocompatibility to ensure their long-term use, patient safety and comfort. Over the years many new devices were introduced to the clinic [2]. However, based on clinical experience, despite undeniable evidences of this treatment effectiveness, many components could still be improved. Most of the currently used blood pumps are made of titanium alloys. The ongoing optimization performed by many producents does not concern only improvements in terms of their function, but also in terms of patient comfort and reduced mortality. According to the information provided by INTERMACS, patient survival drops to 50% after four years of support. However, the VADs, are designed to be wear-resistant and in some cases are used as destination therapy. It is therefore important to further improve the devices biocompatibility in order to reduce the occurrence of complications [3,4]. One of possible complications may be the pump thrombosis and inflow obstruction, caused by the ingrowth of tissue into the lumen of inflow cannula [5-7]. According to reports from clinics and literature, it seems that the solution to this problem may be the use of surface modification [8]. Appropriate topography allows controlled scar tissue formation, which results in reduction of inflammatory processes and the appearance of thromboembolic events [9-10].

Materials and Methods

The paper presents surface modification performed using vacuum sintering intended for use in an VAD inflow cannula. The study presents an analysis of the relationship between surface parameters on the susceptibility of cells to proliferate and the strength of their adhesion to the implant. Samples were prepared from titanium alloy Ti6Al7Nb in form of cylinders Ø14 mm x H 3 mm. During the initial research, the base material was verified for compliance with the standard including the microstructure study, the chemical composition analysis and the study of mechanical properties. Then samples were subjected to tumbling before performing modification. The initial roughness was measured with the use of contact profilometry and was characterised by Ra = 1,5 μm and Rz = 12.5 μm. The sintering process included modifications with the use of Comercially Pure Titanium (Cp-Ti) powder with two different grain morphologies - spherical and irregular. The grain size was changed in rage of 50 to 250 μm. The obtained surfaces were then analysed by scanning electron microscope [SEM]. Additionally, the porosity of obtained surfaces was determined. All samples revealed high roughness with the potential for cell anchoring and scar tissue formation. Fibroblasts were then applied to the samples for three periods of time. The number of cells was assessed on the basis of the stained cell nuclei and the presence of adhesive molecules. In addition, in vivo studies were performed in which samples were implanted into the dorsal muscle of New Zealand rabbits. After 4 and 8 weeks, the specimens were deplanted and the force of detachment of formed tissue from the implant surface was tested. Then the tissue sections were analyzed for inflammatory reactions and histopathology.

Results and Discussion

The results have shown that surface after powder sintering is characterized by high porosity and complex 3D morphology. The obtained roughness was in rage Ra = 21-36 μm. The porosity was in rage 27-49% depending on the size and shape of the powder grains. The permanent connection was obtained at the implant-muscle tissue interface as a result of the surface modification. The detachment force differed by 0.5N depending on the shape of used powder grains.

Conclusions

The presented modification has the potential to anchor cells and form controlled scar tissue on the surface of the implant, both in the context of cardiac and other medical implants.

Acknowledgments

NCBiR: RH-ROT/266798/STRATEGMED-II
National Science Centre, Poland: 2018/31/N/ST8/01085

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