TECHNOLOGY SELECTION OF SURFACE MODIFICATION FOR CARDIAC IMPLANTS USED IN MCS THERAPY

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[ENGINEERING OF BIOMATERIALS 158 (2020) 57]

Introduction

Currently the Mechanical Circulatory Support (MCS) including the Ventricular Assist Devices (VAD) [1] is considered to be a reliable and effective treatment for patients with advanced heart failure (HF). Moreover very often it is the only possible option for patients waiting for heart transplant. After over 50 years of work on MCS devices many new constructions were introduced to the clinic. Recently the extracorporeal pulsatile VAD's are replaced by new generations of fully implantable continuous flow (CF) pumps with non-contact levitating rotor [2]. The solutions currently used in the clinic use the rotor levitation technology, allowing for non-contact work. Clinical experience has provided information that despite many undeniable benefits, new constructions still require improvement to minimize the risk of complications during heart assistance [3,4]. One of complications are the pump thrombosis and inflow obstruction, caused by the ingrowth of tissue into the lumen of inflow cannula [5-7]. The developers of the actual constructions have proven that surface modification allows to control the tissue ingrowth of the external surfaces of the inflow cannula [8–10]. In comparison smooth surface of the cannula results in tissue overgrowth into the lumen flow and may be a source of emboli.

Materials and Methods

The paper presents additive and subtractive technologies of surface modification of titanium alloy for the external surface of the VADs inflow cannula. The proposed technologies included abrasive blasting [AB], laser ablation [LA], atmospheric plasma spraying [APS], powder sintering [PS]. Samples were prepared from titanium alloy Ti6Al7Nb in form of cylinders Ø14mm x H 3mm. The base material was verified for compliance with the standard including the microstructure study, the chemical composition analysis and the study of mechanical properties. The samples were subjected to tumbling before performing modifications. The roughness was measured with the use of contact profilometry. The base material was characterised by Ra=1,5μm and Rz=12,5μm. The aim of the study was to obtain the surface characterized by high roughness with the potential to implant cells, enabling the formation of scar tissue. During the process of all technologies many parameters were subjected to change including: crystal shape and size, medium pressure, angle of the nozzle, power and diameter of the laser beam, size and shape of powder grains. The obtained surfaces were characterized by wettability, contact profilometry, digital microscope [DM] and scanning electron microscope [SEM].

Results and Discussion

The results have shown that surface after PS is characterized by highest roughness of about ≈ Ra=35μm, high porosity ≈64% and wettability ≈100°. The cross section images obtained with the use of DM revealed its complex 3D morphology. Whereas SEM mages highlighted the presence of empty micro spaces that may stimulate cell growth (FIG. 1).

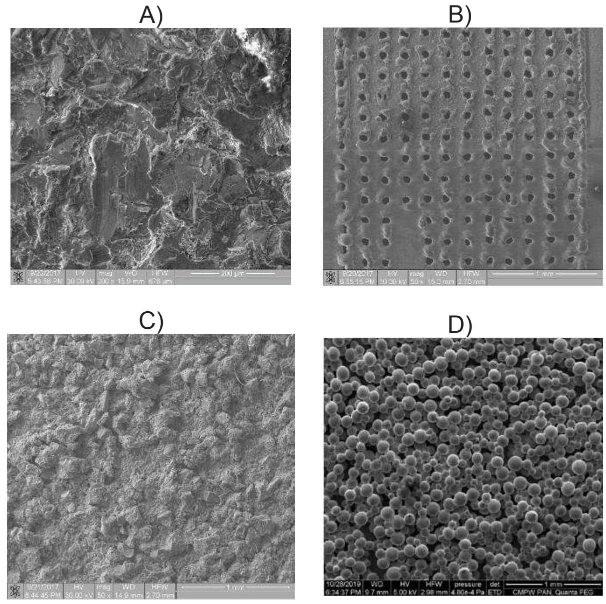

FIG. 1. Sample SEM images for different technologies:
A) abrasive blasting [AB], B) laser ablation [LA],
C) atmospheric plasma spraying [APS],
D) powder sintering [PS]

Conclusions

The surface developed with PS is the most promising for stimulating cardiomyocytes to grow due to its complex 3D morphology, high degree of roughness and porosity. However it is still necessary to perform in vitro tests in terms of cytotoxicity and proliferation, which will be conducted as the next step of the research with the use of fibroblasts and endothelial cells.

Acknowledgments

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

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