

MATERIAL ENGINEERING IN REGENERATIVE CARDIAC SURGERY: "YESTERDAY AND TODAY" & THE ROLE OF MATERIAL ENGINEERING IN THE RECONSTRUCTION OF DEFECTS IN ONCOLOGICAL DISEASES

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Introduction

The first issue currently being developed is the topic of biological valves. It is a continuation of the idea proposed by Professor Zbigniew Religa, according to which based on the natural material of the extracellular matrix, bioactive valve prostheses are created. The valve scaffold is an acellular, xenogeneous or allogeneous tissue on which autologous cells are anodized in vitro or in vivo. Such a valve should have a potential for growth, self-repair and remodeling, similar to native tissue. A bioprosthesis of this kind should significantly bypass the limitations of commercial valve prostheses. The second issue, which is currently being implemented by the consortium partners in an international (Polish-Austrian) research and development project, and whose continuation is planned as part of the implementation project, concerns the mechanical valve for use in heart support chambers (FIG. 1).

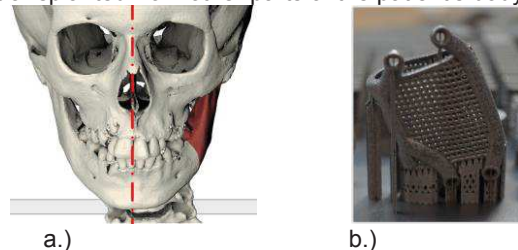


a.) b.)

FIG. 1. Technology readiness level of the heart assist system chamber a.) new valve prototype b.) chamber with implemented chamber.

The main objective is to improve the effectiveness of treatment of patients with myocardial insufficiency, using heart support systems, by developing an innovative material solution consisting in the preparation of a composite material for contact with blood, understood as a combination of a metallic frame with a biocompatible layer in a polymer sheath, which will enable redesigning mechanical heart valves in ReligaHeart EXT (clinically applied VAD) and providing solutions for use in a pediatric blood pump (ReligaHeart PED). The results of the project are of great importance in terms of material, technological and biomedical aspects from the point of view of very active research and development work in Poland on the regeneration of the cardiovascular system developed within the Polish Cardiac Assist System - ReligaHeart. The commercial benefits will result from the possibility of production by Polish Small and Medium Enterprises (SMEs), which have 30 years of successes on the Eastern European market.

Another issue in the field of cardiac surgery is the development of fully hemocompatible blood pump rotors. The innovative ReligaHeart ROT rotary implantable blood pump was developed in the Foundation for Cardiac Surgery Development, a close associate of the consortium members. The chamber is in the preclinical research phase in patients with advanced myocardial dysfunction. It is a mechanical bearingless pump, equipped with a rotor suspended magnetically and hydraulically, which provides a flow of up to 10 l/min at 30-45% capacity. A fully magnetic rotor suspension system, without hydrodynamic bearings, is being developed to reduce shear stress on the blood and protect Von-Willebrand platelets and proteins from damage causing the risk of bleeding. ReligaHeart VASC, is currently under development and is designed for short-term cardiac support in cardiac shock. It has an implantable rotor system with a miniaturized motor and magnetic rotor suspension system. Biomaterial engineering works on the reconstruction of the cranial cavity in case of necessity of skeleton resection of cranial parts. In general, such jaw and mandible resections are difficult and leave large bone losses in patients' faces. The advantage of the new materials is the possibility of local release of radiopharmaceuticals and the safety for high doses of radiotherapy without the risk of necrosis. In the case of benign and malignant tumors affecting the maxillofacial region, jaw bone resection reflects standard therapy (FIG. 2). The resulting large bone losses lead to scars, facial malformations, chewing loss and probably speech. In the next stage, plastic surgery is necessary to restore the correct physical and physiological properties. Reconstruction of the removed parts of the skull is also necessary from a psychological point of view. Although vascularized bone autographs reflect the current gold standard in this type of therapy, only a small part of the bones in the patient's body is available for transplantation. Our research has focused on creating alternative treatment techniques: tissue reconstruction with an innovative mandibular implant that stimulates bone tissue growth. This solution has found particular interest among oncological centers dealing with facial reconstruction, such as Oncology Center in Gliwice. On the basis of the results obtained so far, further development of the issue is planned within the framework of subsequent projects, based on specific clinical cases. A group of about 20 patients with benign tumors (dentic disease, enamel, cyst, giant cell tumor) around the mandibular body or branches will be investigated. The main aim of the research in this area will be to assess the effectiveness of the use of artificial materials for the reconstruction of the mandible in order to replace methods of using free bone lobes vascularized, transplanted from other parts of the patient's body.



a.) b.)

FIG. 2. Jaw implant prototype prepared individually for the patient.

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