IN-VIVO TESTING OF SPONGY TITANIUM IMPLANT BIOCOMPATIBILITY

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INTRODUCTION

For over fifty years, total joint replacement has been a highly successful operation with good long-term resultsproviding anenormous increase in the quality of life of patients suffering from arthritis or related conditions. For these reasons, total hip replacement has been described as 'the operation of the century' [Learmonth et al., 2007]. However, there are approximately 10% of total joint replacements that fail due to implant loosening because of poor bone ingrowth into the implant and mechanical mismatch between the implant and the bone. This project aims to use Electron Beam Melting (EBM) [Heinl et al., 2007] to create lattices with graded porosity and to investigate their potential for improved bone ingrowth in vivo. The use of porous metal has the potential to combine bone ingrowth with a reduced overall stiffness to match the surrounding tissue.

MATERIAL AND METHODS

Implant fabrication. A model of a graded lattice with three layers of different strut thickness was designed; all lattices consisted of 2 mm side length diamond unit cells. The lattice was built on an EBM-S12 (Arcam) using powdered titanium alloy (Ti6Al4V).

In-vivotests.All procedures were conducted in accordance with the Directive 2010/63/EU of European Parliament and Council on the protection of animals used for scientific purposes and the Ukrainian Protocols for Animal Protection. The experiment was conducted on the 5-months old rats (Wistar line) in the laboratory of Sumy State University. In a pilot study, the material was implanted subcutaneously into one animal in the interscapular region under ketamine anesthesia (10mg/kg). Two weeks later the implant was taken out to study the host tissue response for further use in experiments on a bone defect model. This sample was fixed in a 1.25% glutaraldehyde solution and a 2% osmium solution and then dehydrated in ascending alcohols (60%, 70%, 80%, 96% and 100%). Silver was sprayed on the sample in the VUP-5 vacuum source and then it was examined with scanning electron microscopy to identify tissue and cells on the surface of the material.

RESULTS

As the skin was cut, it was noticed that the top surface of the material was covered with a thin fibrous capsule. The bottom of the sample was attachedto the subcutaneous fatty tissue and had connective tissue ingrowth, which was full of small blood vessels.

The surface of the material was examined with scanning electron microscopy and showed that the surface of the implant was covered by a dense layer of connective tissue with collagen fibrillae of different thickness and orientation. This layer of connective tissue also contained cells with a prolateshape, which is typical for new fibroblasts and can indicate active fibrogenesis. Connective tissue, which covered the material, established its own pore system; the diameter of these pores was much smaller than the pore size of the implant. There were small vessels and capillaries on the sample surface which had grown into the connective tissue pores of the implant itself. A peculiarity of connective tissue growth is its ability to penetrate the material pores. This demonstrates that the titanium implant has tissue-conductive features.

Thus, the conducted experiment shows porous titanium implant biocompatibility and existence of conductive features. This results leads to further research concerning this materials possible usage in osteoplasty.

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