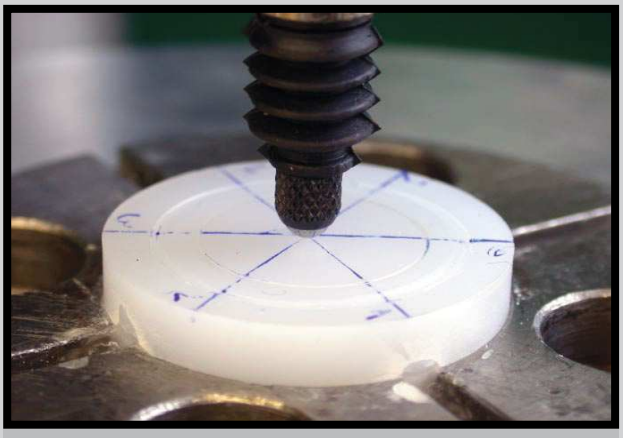

FIG.4. The UHMWPE disc No. 1 after finishing the test.

Material of RING	Material of DISC	Wear volume [mm^3]
Zirconia ceramics (Y-TZP)	Alumina ceramics	0.16
Vitalium alloy (Co-Cr-Mo)	Irradiated UHMWPE (crosslink) – 100 kGy	4.78
Vitalium alloy (Co-Cr-Mo)	UHMWPE (no crosslink)	5.51
Alumina ceramics (Al_2O_3)	Pressed UHMWPE	5.62
Titanium alloy (Ti_6Al_4V) with DLC	UHMWPE	6.61
Zirconia ceramics (Y-TZP)	PEEK (PolyEtherEther-Ketone)	7.59

TABLE 1. Final parameters of mechanical testing.

We found out the worn volume on the UHMWPE modified by crosslink is less than on the UHMWPE without modification and less then other combinations of biomaterials too. The results show the modification by crosslink is for UHMWPE material useful. Only wear resistance of combination ceramics x ceramics is better, but this combination is only theoretical and is used for comparison. For next development it is purposeful to finish tests with other bone-substitute materials and increase the database with wear resistance evaluation.

Acknowledgements

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STRUCTURE AND PROPERTIES OF CERAMIC GRAFTING MATERIAL

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Introduction

The problem on developing bone substitutes consists in difficult imitation of a chemical composition, micro- and macrostructure as well as in provision of physical-mechanical, electrical, and other properties of a material that would promote the renewal of normal metabolism processes in living cells. At present endoprosthetics uses various materials but their properties much differ from those of the bone [1, 2]. Use of the bone tissue itself as an implant is not always possible because of the protein biocompatibility. As a result of this, the transplanted implant is rejected and loses its mechanical properties [3]. However, a new approach is possible to search and develop an artificial implant. It means the preparation of a biocompatible, slowly resolved material and its replacement by the living bone tissue due to natural regeneration of the cells of bone substance. Optimal compositions and the structure of such materials are being sought at the Research Centers of some countries and Belarus too. The present work is devoted to preparing a porous grafting ceramic material and to performing medical-biological experiments on it.

Methods

Samples of porous implants were fabricated from natural compounds containing calcium and phosphate as well as magnesium phosphate and calcium carbonate admixtures. Heat treatment was made within a special step-by-step regime involving isothermal annealing. Moulding and mechanical processing were conducted at certain stages. For the influence of the heat treatment temperature on the structure and properties of porous ceramics to be studied, the implant samples were annealed in air over the temperature range 300-1400^{0}C, their crystal and porous structures as well as the physicochemical and mechanical properties were examined. The X-ray and IR spectroscopic methods were adopted to investigate the phase composition. The morphology of the sample surface was studied with the use of the scanning electron microscope and the sections of the bone and muscle tissue dyed with hematoxylin and eosin, with the use of the optical microscope. The physicochemical and mechanical properties were determined by the standard methods.

Results

As observed in the IR spectroscopic and X-ray phase analysis, the porous ceramic material annealed at 1000^{0}C is a complex calcium-phosphate compound containing OH-groups. When thermally treated, the porous structure of calcium-phosphate ceramics and its properties change. After heat treatment of the material within 300-700^{0}C the

pore sizes are 500-1000 μm, and as the annealing temperature increases up to 1200-1400^{0}C they decrease up to 40-300 μm. The porous structure of the dividing walls between the macropores changes, too. The electron microscopic study of the microstructure of the material surface shows that deep micropores are present in the dividing walls between the macropores of the samples having an annealing temperature of 700^{0}C. At 900^{0}C the spherical particles, i.e. globules are formed, followed by the formation of micropores. As the temperature elevated up to 1000^{0}C the globules sintered into elongated conglomerates and the macropores were formed. After 1200^{0}C annealing the material represented the sintered particles with a developed surface and slotted pores.

The mechanical and physical-chemical properties of the material changed depending on the heat treatment temperature (500-1100^{0}C). The density increased from 1.0 to 2.0 g/cm^3, the strength under compression increased 3.5-4 times while the porosity decreased from 70 to 45% and specific surface - from 52 to 1.5 m^2/g, respectively.

To perform medical-biological studies the porous calcium-phosphate samples were chosen, from which experimental implants were fabricated in the form of 6x4x2 mm plates, whose strength was not below 6-10 MPa and whose porosity amounted to 37-40%. The implant samples were transplanted into the defect places drilled in the rabbit's mandible. In control group the bone defects were filled with blood clot. In 7, 14, 21, 30 days and 6 months the animals were taken out of experiment, and bone and soft tissue near and inside the defects were examined.

Discussion

The obtained results have revealed that the implant is characterized by two levels of pores: macropores 300-400 μm in size in the material volume as well as by micro- and transient pores up to 100 nm located over the material surface of the dividing walls. The experiments have supported that in 14–21 days at the implant - cortical or spongy bone boundary the muscle and bone tissue gradually germinates into the implant holes.

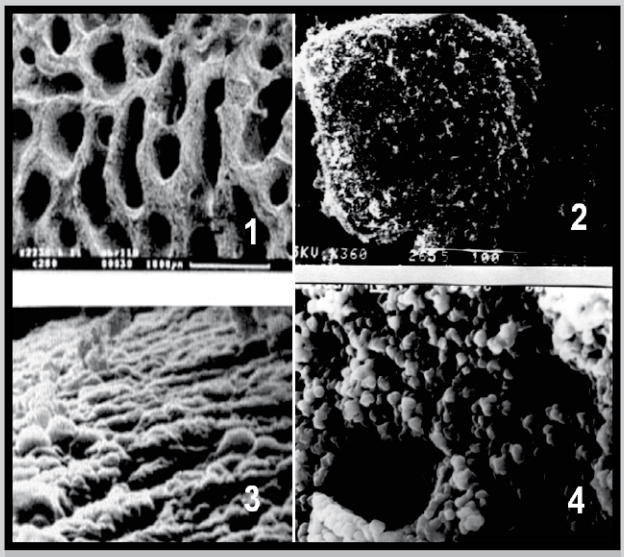

FIG.1. Microstructure of block material - 1, granule - 2, wall between macropores in block - 3 and in granule - 4, (SEM images: 1 and 2 – 500x, 3 and 4 – 10000x).

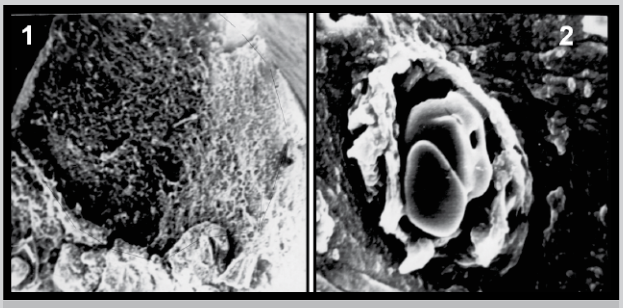

**FIG.2. The porous implant into bone defect (dark part in center) - 1, and protein substance into macropore of implant - 2.
(SEM-images: 1 – 75x, 2 – 1000x).**

The formation of protein substance in the samples of the calcium-phosphate implants being in contact with the bone for 21 days developed so intensely that it was impossible to separate the implant from the bone, not disturbing its completeness. New formations on the ceramic material side and vessel fragments were seen on the bone side. After decalcification some part of the implant dissolved, the albuminous substance and forming trabeculas of the bone were preserved on the implant surface and in its porous volume. The study of the samples transplanted into the rabbit's mandible and being there for 30 days pointed not only to the presence of contact but also to the formation of a new bone at a place where the implant is transplanted. No inflammation at the contact place of the bone and the implant was observed for all experimental times. In 6 months, a new bone tissue was formed in the rabbit's mandible at the defect place, and the implant was resolved partially. This fact was confirmed by the results of the visual and microscopic investigations.

Conclusions

The developed grafting material is compatible and promotes the bone regeneration process.

Acknowledgements

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