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# DEVELOPMENT OF A BIODEGRADABLE MATERIAL FOR BONE REGENERATION BASED ON SILICON COMPOUNDS

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**ABSTRACT** — In the course of this study we established that the laboratory sample in granulated form developed by us has a stimulating effect on the growth and proliferation of osteoblasts. Analysis of the data (CT, MRI) of the biological material obtained from the animals withdrawn from the experiment showed a statistically significant replacement of the artificial defect with bone tissue with signs of restoration of the cortical plate. The analysis of the CT results indicates that this method is sufficiently informative in assessing the regeneration of the trabecular structure of bone tissue. The study (MRI) of the bone material obtained from the animals participating in the experiment showed that when the osteoinductive material was integrated, the defect zone was replaced by 90%. In the projection of the defect, the newly formed tissue of a homogeneous structure was determined, corresponding in density to bone tissue with a high degree of mineralization. There was a complete restoration of bone tissue in the projection of the defect.

**KEYWORDS** — osteoplastic materials, bone defects, bone powder, dental implantation.

## INTRODUCTION

One of the most urgent problems of traumatology, orthopedics, surgical dentistry and maxillofacial surgery is the problem of replacing bone defects. A distinctive feature of these problems is the lack of expression of the natural regenerative processes of bone tissue. Given that the spontaneous restoration of the integrity of bone tissue in the area of the defect is either impossible or excessively long, therapeutic measures are based on the use of various bone-substituting (osteoplastic) materials, which are designed to enhance the activity and effectiveness of the recovery process.

The most effective of the osteoplastic materials is the patient's own (autogenous) bone tissue. However, the need to expand or create a new surgical field to obtain fragments of the patient's own bone tissue from

donor sites (ilium, ribs, mandible), complication and lengthening of surgical intervention, increased risk of complications, the specifics of the somatic status and preferences of patients impose restrictions on the use of autogenous bone tissue and force the use of products available on the market.

However, the vast majority of osteoplastic materials on the market are a kind of *biologically active additives* — they only supply structural components necessary for the formation of bone tissue in the defect zone, therefore they have low or extremely moderate effectiveness.

## Purpose of the study

The purpose of this study was to establish the regularities of morphological changes in bone tissue of laboratory animals for correction of defects in the maxillofacial region using osteoplastic material.

## MATERIALS AND METHODS

Examination (CT, MRI) of biological material obtained from animals were used in the experiment. The results of the experiment were registered.

In our experiments we fully adhered to Ethical Guidelines for the Use of Animals in Research (EU Directive 2010/63/EU).

The object of the CT study was the bone tissue of the lower jaw of a rabbit obtained 90 days after the integration of experimental osteoplastic material, fixed in 10% buffered formalin in accordance with the rules for pathomorphological and histological studies.

There was a complete restoration of bone tissue in the projection of the defect (Fig. 1). The newly formed bone looked immature: the bone beams were uneven in shape and size, randomly arranged.

In CT with the reconstruction of the three-dimensional image, the replacement of the defect with bone tissue with the restoration of the cortical plate was determined. The CT data allowed us to visualize the formation of the trabecular structure of bone tissue in the projection of the defect at a given regeneration period of 90 days (Fig. 2).

The analysis of CT results in bone regeneration showed its informative value in assessing the trabecular

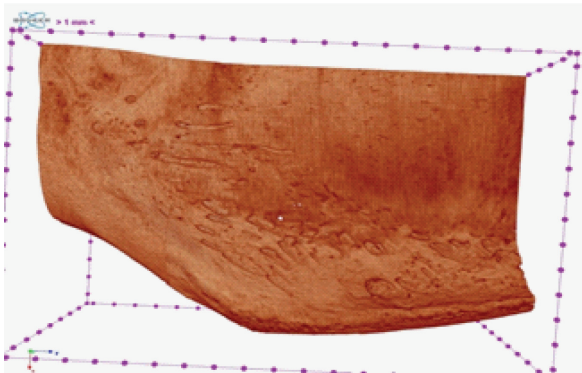


Fig. 1. Three-dimensional 3D model of bone tissue in color

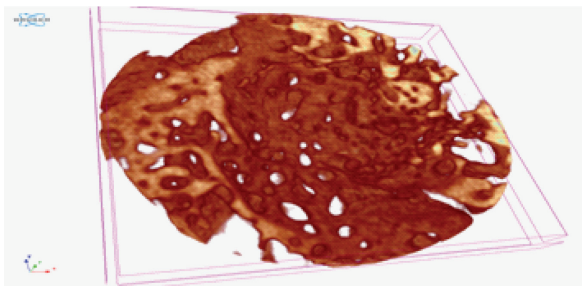


Fig. 2. Formation of the trabecular structure of bone tissue. Three-dimensional 3D model in color

structure of bone tissue. The reconstruction of three-dimensional images made it possible to determine the spatial localization of structures in the projection of the bone defect due to the absence of the overlap effect, to outline the surface structures in relief and to evaluate the complex three-dimensional relationships between bone and soft tissue fragments.

The study (MRI) of the biological material obtained from the animals in the experiment showed that when the osteoinductive material was integrated, the defect zone was replaced by 90%.

In the projection of the defect, the newly formed tissue of a homogeneous structure was determined, corresponding in density to bone tissue with a high degree of mineralization. There was a complete restoration of bone tissue in the projection of the defect (Fig. 3). The newly formed bone looked immature: the bone beams were uneven in shape and size, randomly arranged.

Histological examination of the bone in the defect area of the lower jaw of rabbits in the time interval from 14 days till 3 months has shown that the healing of the bone wound, the features and the rate of formation and maturation of bone regenerate were as-



Fig. 3. MRI, three-dimensional image reconstruction

sociated with the osteoinductive and osteoconductive properties of the experimental drug.

## CONCLUSION

Control studies of the biological material obtained from the animals used in the experiment confirmed our research.

The results of computed tomography revealed the persistence of the tendency to increase the density of regenerate in animals. By the end of the experiment, the bone defect was completely closed. Along the edges of the former opening, the trabeculae were partially resorbed and the bone began to transform into a lamellar bone with a developed system of haversoid channels. Bone tissue rearrangement in the area of the formed regenerate in animals with local administration of the experimental drug occurred at an earlier time, which was determined by the density of the regenerate, this is a sign of a sufficiently high degree of biocompatibility of bone tissue and experimental osteoplastic material (Fig. 4).

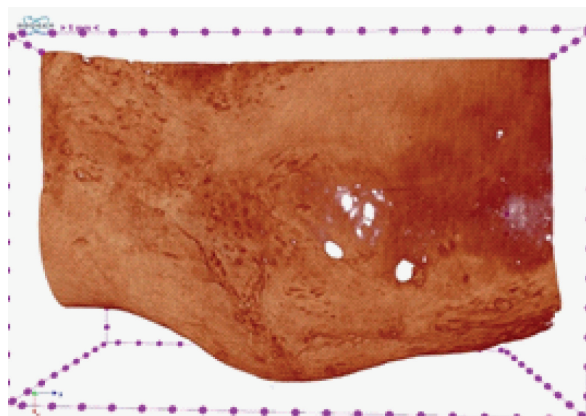


Fig. 4. 3D volumetric model in color

The MRI results confirmed that the implanted material corresponds to the bone tissue in density and structure, and the regenerate density is uniform (Fig. 5).

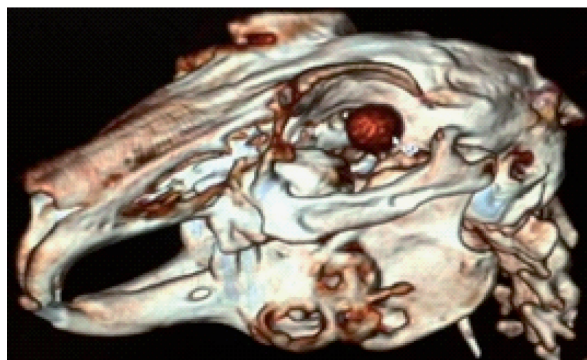


Fig. 5. MRI of the bone tissue of the lower jaw

On the 14<sup>th</sup> day after the operation, the formation of immature bone tissue began, by the 20<sup>th</sup> day, the bone tissue already filled most of the volume of the defect (two-thirds). At the same time, there was a certain *maturation* of the regenerate, characterized by an orderly arrangement of fibrous structures, although it still consisted of osteoid beams. Part of the regenerate had a *chondroid* structure. 1 month after the operation, the defect was almost completely filled with bone regenerate, the bone marrow was absent (Fig. 6). After 2 months, the reticulofibrous bone tissue matured and was partially replaced by lamellar bone. After 3 months, the bone tissue of the regenerate has already fully matured, compacted, clear lines of adhesion appeared, and osteons were formed (Fig. 7).

The bone regenerate was similar in structure to the spongy bone of the operation area, only slightly different in thickness and pronounced signs of bone remodeling.

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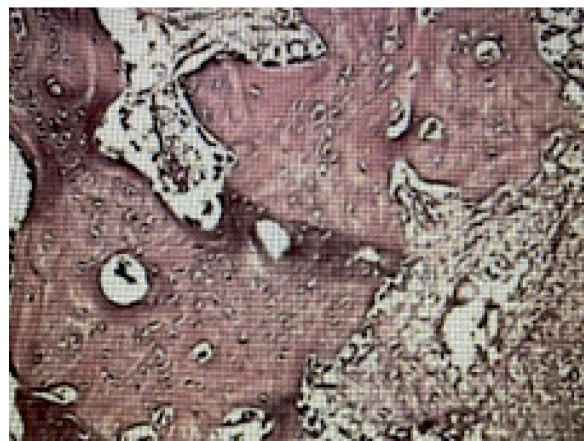


Fig. 6. The defect is filled with maturing regenerate, the bone compaction looks weak. Stained with hematoxylin and eosin

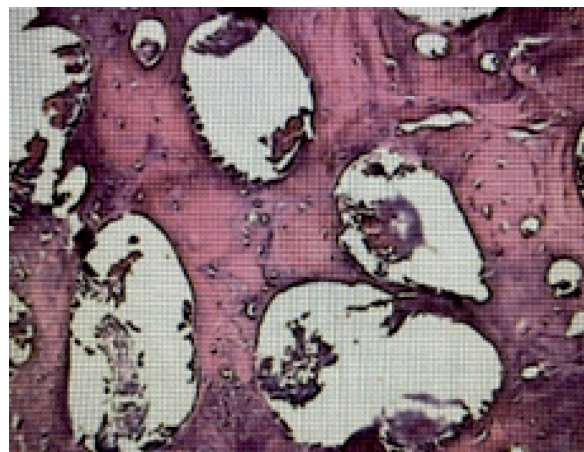


Fig. 7. Relatively mature bone regenerate with compaction phenomena. Stained with hematoxylin and eosin