INTERNATIONAL JOURNAL OF INTEGRATIVE AND MODERN MEDICINE

Preclinical Experimental Study of Osteoplastic Material Based on Hydroxyapatitis for Surgical Dentistry

Mukimov O.A.[1], Azimov A.M.[2], D.R. Usmanova[3]
[1,2,3]*Department of Surgical Dentistry and Dental Implantology, Tashkent State Medical University, Uzbekistan*

Abstract:
Modern regenerative medicine is aimed at expanding the capabilities of clinicians in stimulating natural bone regeneration processes and developing artificial biomaterials for the restoration of lost tissues. This work is devoted to the experimental study of the effectiveness and safety of osteoplastic material based on hydroxyapatite, intended for use in surgical dentistry, including during sinus lifting operations.

Keywords: Hydroxyapatitis, Osteoplastic Material, Bone Regeneration, Biocompatibility, Toxicological Assessment, Sinus Lifting, Surgical Dentistry

Introduction

Currently, despite significant achievements in the field of dental implantology, the problem of rehabilitation of patients with pronounced atrophy of the maxillary bone tissue remains insufficiently studied [1], [2]. This is especially relevant for the maxilla, where bone tissue reduction often requires surgery to raise the floor of the maxillary sinus using osteoplastic materials - what is called sinus lifting. The effectiveness of this surgical intervention is largely determined by the correct choice of methodology and the characteristics of the applied osteoplastic material [3].

Purpose of the study: To evaluate the effectiveness and safety of osteoplastic material based on hydroxyapatite for parenchymal organs in the experiment.

Methodology

To achieve this goal, collagen-containing hydroxyapatite developed at the Academician A.S. Sadikov Institute of Biochemistry was used. Biomaterials were administered to 18 rabbits aged 6 months to 1 year. "California" male rabbits

For morphological examination, pieces of parenchymal organs of the liver, kidneys, and stomach of the control and experimental groups of experimental animals were selected. Collagen in a solution of the vitreous body was administered to the animals in the right gum region from the inner side into the thickness of the soft tissues, in other groups with a solution of calcium gluconate and a combination of calcium gluconate with collagen. On the 14th day of the experiment, animals were slaughtered and parenchymal organs were extracted to determine the cumulative toxicity of these drugs. 1.0 cm pieces were cut from the parenchymal organs and placed in a 10% formalin fixing solution for 24 hours, then the pieces were passed through a battery of alcohol, chloroform, alcohol+chloroform, and two jars of chloroform. Then they were loaded into a thermostat at 37 degrees for 1-2 hours, and 57 degrees for impregnation for 1 hour, after solidification, paraffin blocks were cut. Serial cuts were prepared from the finished blocks. The glass was coated with protein and pierced with a spirit lamp, the cut materials were attached to the glass and colored with hematoxylin and eosin. The prepared preparations were viewed under a BIO BLUE binokullary microscope with an adapter and an euromex microscopen BV camera. As a result of morphological examination of organs in the control group.

Result and Discussion

Histological examination of organs stained with hematoxylin and eosin (objective magnification 10×10) revealed the following morphological changes.

Heart (Fig. 1, 6, 8). In the myocardium, muscle fibers are mainly preserved, cardiomyocytes form ordered bundles [4]. The nuclei of cardiomyocytes are clearly defined, have an elongated or rounded shape, and the transverse striated muscle fibers are preserved [5], [6], [7]. In the interfibrous layers, fine

dust-like droplets of fat inclusions are detected, as well as a small number of lipocytes. Intermediate edema is weakly expressed. The vessels are in places sharply dilated, full-blooded, with thickened walls [8], [9].

Spleen (Fig. 2). Red pulp is poorly represented, contains hemolyzed erythrocytes. The white pulp is well-defined, represented by lymphoid follicles in a state of hyperplasia, which indicates the activation of the organ's immunocompetent structures [10], [11].

Kidney (Fig. 3). In the field of view, straight and curved renal tubules, lined with epithelium with clearly distinguishable nuclei, are determined [12]. A small amount of clear contents is detected in the lumen of the tubules. The structural organization of nephrons is generally preserved [13].

Lungs (Fig. 4). Alveoli are predominantly free, their lumen is not filled with exudate. The intercellular septa are thin. The lumen of the bronchus is widened, lymphocytic infiltration is observed around it [14]. The vessels of the lung tissue are in a hyperemia state.

Liver (Fig. 5, 13). The lobular and beam structure of the liver is preserved. Hepatocytes contain nuclei of round shape, intensely colored. In the central parts of the lobules, dusty and small-droplet fat inclusions are found, which corresponds to focal fatty degeneration [15]. The vessels are full of blood. In the periportal zones, moderate round cell infiltration is detected. At greater magnification, linear lymphohistiocytic infiltration, vascular hyperemia, and focal dystrophic changes in hepatocytes are observed.

Detailed photographs from the microscope are shown below. (Fig. 1-8).

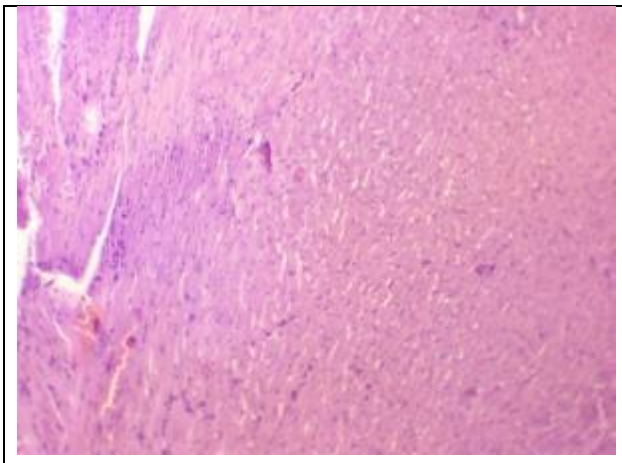


Figure 1. Heart - in the muscle fibers of the nucleus, small droplets of fat inclusions are detected in the interfibrous layers. Staining with hematoxylin and eosin. U.v. ob. 10x10.

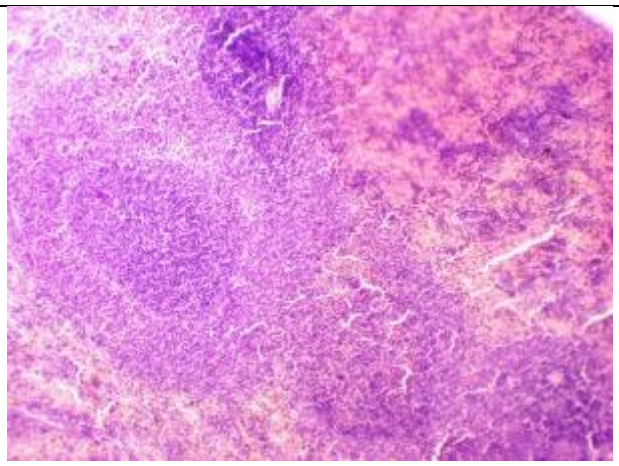
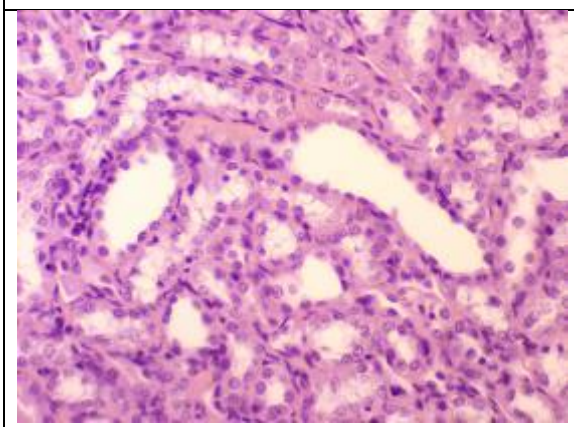
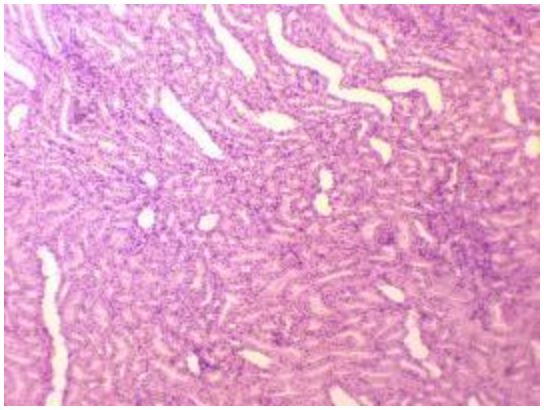


Figure 2. The spleen is a sparse red pulp with hemolyzed erythrocytes. The white pulp contains lymphoid follicles in a hyperplastic state. Staining with hematoxylin and eosin. U.v. ob. 10x10.



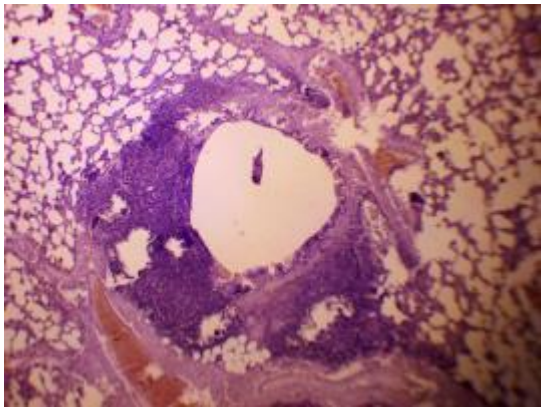
А



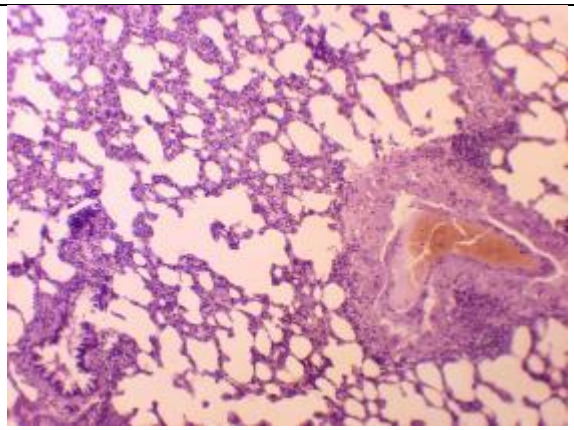
Б

Figure 3. Kidney - in the field of view, straight and convoluted tubules contain nuclei in the epithelium, in the lumen of the tubules there is a slight transparent mass. Staining with

hematoxylin and eosin. U.v. ob. 10x10.



А



Б

Figure 4. The lungs - the alveolar lumen is free, the interalveolar septa are thin. The bronchial lumen is dilated, surrounded by lymphocytic infiltration and hyperemia of blood vessels. Staining with hematoxylin and eosin. U.v. ob. 10x10.

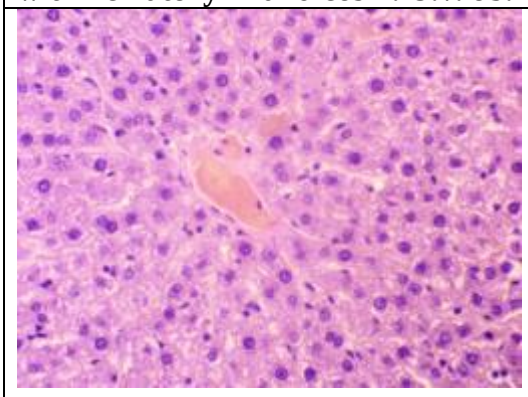


Figure 5. The liver has a beam-like structure, and the rounded nuclei in hepatocytes are darkly colored, revealing dust-like droplets of fatty inclusions in the central parts of the lobe. Staining with hematoxylin and eosin. U.v. ob. 10x10.

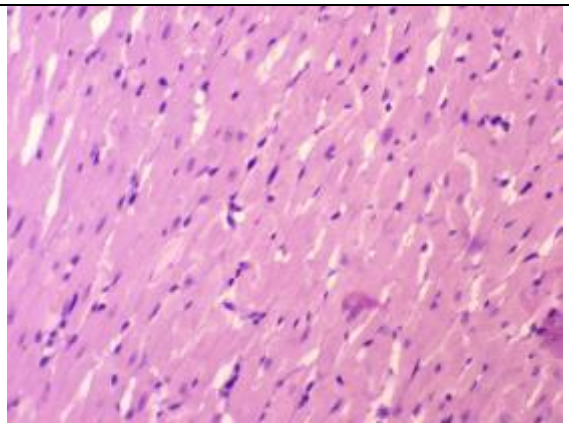


Figure 6. Myocardium - muscle fibers contain nuclei of elongated shape, transverse stripes are preserved, interstitial edema is insignificant. Staining with hematoxylin and eosin. 10x10 cm.

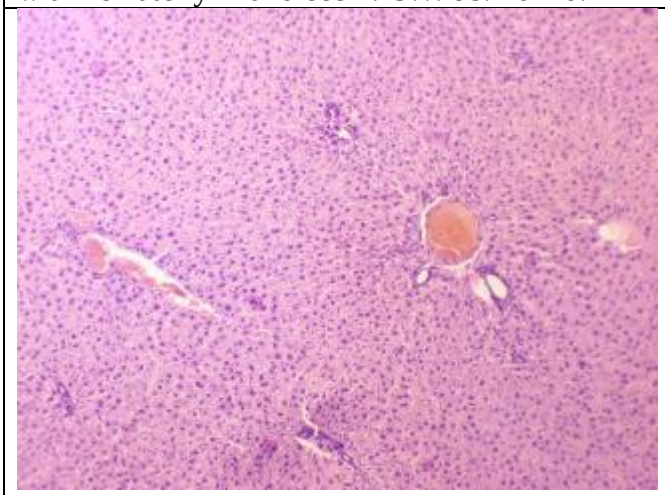


Figure 7. The liver has a beam-like structure of hepatocytes, blood vessels are full-blooded, and periportal infiltration is moderately round-celled. Under a large magnification, linear lymphohistiocytic infiltration, vascular hyperemia, and focal small-droplet fatty degeneration of hepatocytes are observed. Staining with hematoxylin

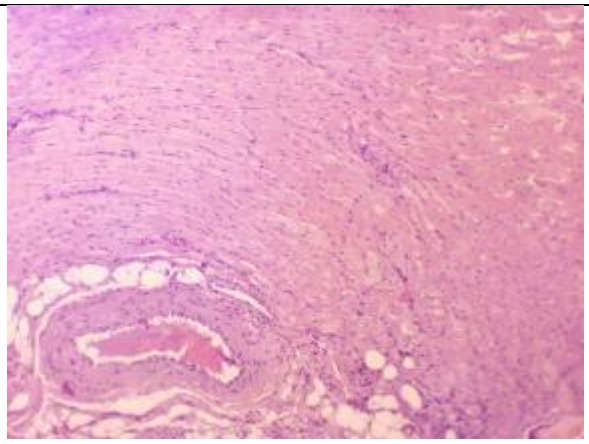


Figure 8. Heart - cardiomyocytes form bundles of fibers, nuclei in them are determined, the vessel is sharply dilated, filled with blood, the wall is thickened, a small number of lipocytes. Staining with hematoxylin and eosin. 10x10 cm.

and eosin. 10x10 cm.	

Conclusion

In this experimental preclinical study, the effectiveness and safety of a new osteoplastic material based on hydroxyapatite were assessed. The experiment was conducted on a rabbit model. To study the osteoregenerative properties of the material, it was used in sinus lifting in the maxillary sinus area. To determine biocompatibility and possible toxic effects, the drug was additionally administered to the parenchymal organs of experimental animals.

Assessment of the research results included clinical-morphological and toxicological analyses to study tissue reactions, signs of inflammation, degenerative and necrotic changes, as well as features of reparative processes. The obtained data allow us to judge the potential of using osteoplastic material based on hydroxyapatite in surgical dentistry and implantology, as well as its safety during experimental use.

The results of histological examination of the parenchymal organs of experimental animals (rabbits) using osteoplastic material based on hydroxyapatitis showed the presence of moderately pronounced and unpronounced morphological changes represented by fatty degeneration and venous hyperemia, which may be associated with hypoxic processes. The identified changes are nonspecific and are likely due to a combination of factors, including the conditions of keeping the experimental animals, the peculiarities of the diet, as well as the influence of operational and experimental stress, rather than the direct toxic effects of the studied material. In all series of experiments, the histological structure of internal organs generally maintained its architectonics.

Signs of pronounced toxic effects, including necrotic changes, parenchyma destruction, and gross vascular disorders, were not detected. Thus, the obtained data indicate that the use of osteoplastic material based on hydroxyapatite does not lead to the development of toxic damage to internal organs and can be considered safe under experimental preclinical studies.

References

[1] J. Arcas-Sanabre, J. Gutierrez-Santamaria, J. López-López, R. Ayuso-Montero, and E. Velasco-Ortega, “Horizontal augmentation of the maxillary alveolar ridge to change the prosthetic profile: Clinical and radiological results of a retrospective study,” Journal of Stomatology, Oral and Maxillofacial Surgery, vol. 121, no. 1, pp. 25–29, 2020.

[2] S. A. Bayadilovich and S. K. Erkinovich, “The role of preliminary expansion of soft tissues before GBR,” World Bulletin of Public Health, vol. 13, pp. 206–209, 2022.

[3] D. Isanova and O. A. Mukimov, “Evaluation of the sensitivity of microflora of the periodontal pocket to antibacterial agents in the conditions of the rural population,” in Library, vol. 19, no. 2, pp. 157–159.

[4] O. I. Radjabov, D. R. Usmanova, K. E. Shomurodov, A. Y. Atazhanov, and A. S. Turaev, “Preclinical studies of injectable collagen solution,” in Proc. III Int. Sci.-Pract. Conf. “Modern Pharmacy: New Approaches in Education and Current Research”, 2023, pp. 128–129.

[5] O. I. Radjabov, D. R. Usmanova, A. Y. Otajonov, K. E. Shomurodov, and A. S. Turaev, “Biological activity of collagen-based biomaterials,” in Proc. Int. Conf. “Actual Problems of Development of Bioorganic Chemistry”, Nov. 13–14, 2023.

[6] D. R. Usmanova and K. E. Shomurodov, “Analysis of the use of collagen preparations for increasing gingival volume,” Integrative Dentistry and Maxillofacial Surgery, no. 1, pp. 9–16, 2023.

[7] A. B. Shukparov, K. E. Shomurodov, and R. S. Mirkhusanova, “Microcirculation of the mucosa of the alveolar ridge during preliminary soft tissue expansion and guided bone regeneration (clinical trial),” European Journal of Modern Medicine and Practice, vol. 2, no. 9, pp. 64–72, 2022.

[8] K. E. Shomurodov, R. S. Mirkhusanova, and N. Sh. Zhurakulov, “The significance of keratinized gingiva in prosthetics supported by dental implants and methods of increasing its width (review),” Integrative Dentistry and Maxillofacial Surgery, vol. 2, no. 1, pp. 82–89, 2023.
[9] D. Buser, W. Martin, and U. Belser, “Optimizing esthetics for implant restorations in the anterior maxilla,” International Journal of Oral & Maxillofacial Implants, vol. 19, pp. 43–61, 2004.
[10] J. Buser, D. Dula, H. Belser, U. Hirt, and H. P. Berthold, “Localized ridge augmentation using guided bone regeneration,” International Journal of Periodontics and Restorative Dentistry, vol. 13, pp. 29–45, 1993.
[11] T. Berglundh, I. Abrahamsson, and J. Lindhe, “Bone reactions to long-standing functional load at implants,” Journal of Clinical Periodontology, vol. 32, pp. 925–932, 2005.
[12] N. P. Lang and J. Lindhe, Clinical Periodontology and Implant Dentistry, 6th ed. Oxford, UK: Wiley-Blackwell, 2015.
[13] D. Hämmerle and J. Jung, “Bone augmentation by means of barrier membranes,” Periodontology 2000, vol. 33, pp. 36–53, 2003.
[14] M. A. Nevins and H. L. Mellonig, “Enhancement of the damaged edentulous ridge to receive dental implants,” International Journal of Periodontics and Restorative Dentistry, vol. 12, pp. 96–111, 1992.
[15] T. Urban, Z. Lozada, and G. Jovanovic, “Vertical ridge augmentation and guided bone regeneration,” Clinical Oral Implants Research, vol. 20, pp. 69–81, 2009.