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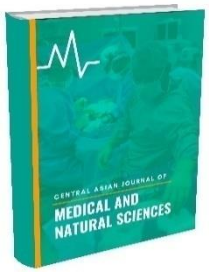

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Exploring Chitosan-Derived Biocomposites for Advanced Applications in Dental Implantology (Literature Review)

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Abstract: The unique properties of Bombyx mori chitosan from silkworm pupae (biocompatibility, bioresorbability, non-toxicity, antibacterial properties, hemostaticity) will find wide application in therapeutic, surgical and orthopedic dentistry. The use of chitosan from local sources of raw materials will be in demand for the creation of bioactive coatings on dental implants in domestic dentistry.

Key words: dentistry, dental implants, composite materials, osseointegration, chitosan, biocompatibility, bioresorbability, antibacterial activity.

Introduction. At present, active attempts are being made to enhance osseointegration due to the inclusion of new generation composite bioresorbable materials in the implant coatings. One of the promising biomaterials for this turned out to be chitosan, which has a number of properties that can bring it to the forefront of prosthetics: it is non-toxic, biocompatible, bioresorbable, and moderate antibacterial properties [1].

Chitosan is obtained from chitin and the possibilities of its production technology have not yet been fully exhausted. The chains of the chitin linear aminopolysaccharide are interconnected by hydrogen bonds. Each chain is predominantly composed of repetitive N-acetyl-amido-2-deoxy-β-D-glucose residues and much less glucosamine residues.

Both types of residues are linked in chains by □ (1 → 4) -glycosidic bonds (Fig. 1).

The pronounced chondro- and osteoinductive effects of three-dimensionally organized chitosan have been confirmed by numerous experiments [2,3].

The technological aspects of creating such surfaces, as well as the results of their osseointegration in vivo, are currently being actively studied.

Prospects for the use of chitosan are implantology, tissue engineering and the development of means for the delivery of drugs to organs and tissues. Chitosan is found in the outer skeleton of some crustaceans, insect cuticles, fungal cell walls, and plankton.

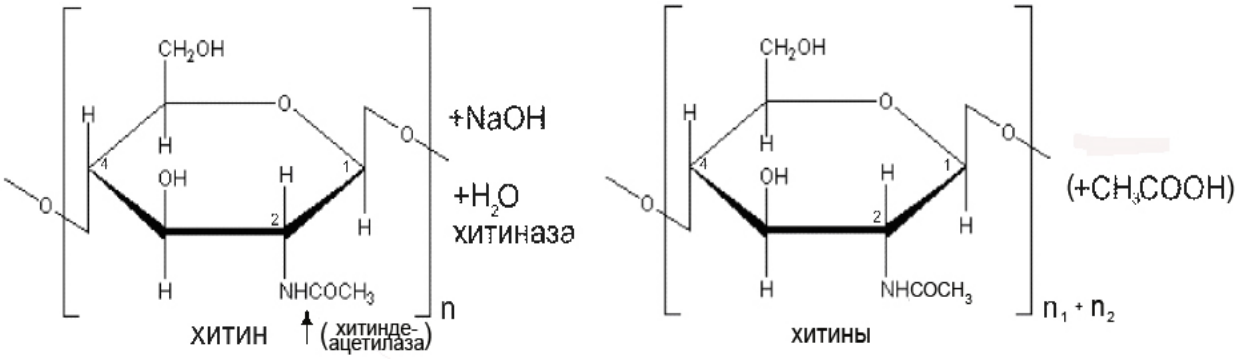

Fig. 1. Depolymerization of chitin n with hydrolysis of a part□(1 → 4) glycosidic bonds with the participation of alkali, or the hydrolytic enzyme chitinase with the formation of two polymers n1 + n 2. The arrow shows the site of deacetylation by hydrolysis of the acetamide bond with chitin deacetylase with the formation of a protonated amino group R-NH3 and acetic acid (in parentheses) instead.

The use of chitosan and its derivatives in dentistry...

Italians R. Muzzarelli et al. Made a great contribution to the study of chitosan in dentistry. [4-7]. In particular, they used chitosan in combination with ascorbic acid in the treatment of generalized periodontitis [5]. By special treatment, a gel was obtained, which was injected into deep pockets after open curettage. 2 months after the treatment, the mobility of the teeth approached the norm, while before the treatment, the mobility of the II degree was clinically determined. The depth of the pathological pocket decreased, the level of epithelial attachment was restored.

Chitosan enhances local immunity in the treatment of patients with acute purulent periostitis using a photosensitizer based on chitosan and methylene blue in the IR range. The level of lysozyme in the oral cavity increases by 3 times. For acute purulent periostitis of the maxillofacial area in outpatient settings, it is recommended to use a 1% solution of chitosan in 0.25% HCl in combination with methylene blue and LILI for therapeutic purposes. Treatment of acute purulent periostitis according to this method improves the result of therapy, including a reduction in the duration of treatment by 1-2 days in comparison with traditional methods of treatment. The complete cessation of the discharge and the cleansing of the wound occurred on average 4.3 +/- 0.8 days after the operation, which, on average, 2.9 days earlier than in patients treated with traditional methods.

Irradiation of LILI is necessary at each dressing after preliminary cleaning of a purulent wound from necrotic tissue and treatment with a solution of chitosan in combination with methylene blue.

A. Maygurov et al. (2006) used 2% chitosan ascorbate gel (degree of deacetylation 95%, MW 180-200 kDa) and zinc oxide in a ratio of 1: 2 in the treatment of deep caries [9]. There was no toxic effect on the pulp.

A high bacteriostatic effect due to agglutination of microbes and a pronounced anti-inflammatory effect due to the activation of hyaluronidase and □-glucuronidase. 3 months after the application of the paste, dense obliteration of the dentinal tubules and well-pronounced mineralization of the reparative dentin were visible. There was no clinical response to stimuli, the color of the tooth crown was preserved, and the electroexcitability indicators returned to normal.

When studying the antibacterial activity of chitosan gel preparations on a mixed culture of bacteria isolated from root canals with destructive periodontitis, 8% chitosan gel had the most pronounced

antibacterial effect. Bone tissue was completely restored after 12 months. in 62.2% of patients, it partially recovered in 32.7% with a tendency to complete recovery in the long term. Gel form of 38% water-soluble chitosan ascorbate with metronidazole (MM 70 kDa, degree of deacetylation 87%, particle diameter less than 160 microns) in the treatment of chronic catarrhal gingivitis promotes rapid elimination of gingival inflammation, enhances microvesicular transport of substances through the capillary lumen, reduces edema and restores the structural organization of the gums ...

In the treatment of moderate chronic periodontitis, a sponge containing 8% chitosan ascorbate, 2% bovine collagen acetate, metronidazole at a dose of 0.016 mg / cm 2 was used. A sterile sponge 0.3x0.3 cm in size was inserted into the periodontal pocket under a protective bandage once a day with an interval of 2 days. Clinically, there was a decrease in the bleeding of the gums, the mobility of the teeth decreased, the pain sensations when eating stopped. The anti-inflammatory effect was 60.5%. As a result of the studies, a positive effect of the action of chitosan in various pathologies of the oral cavity was noted.

A porous implant with chitosan and collagen, together with bone morphogenetic protein (BMP-7) and periodontal ligament cells, Zhang Y. et al. (2007) were introduced into the mandibular defect in dogs. Young bone formation was more intense in the experiment than in the control without chitosan, which was confirmed by laser confocal microscopy, an increase in the activity of alkaline phosphatase - a marker of osteoblasts, an increase in the content of osteopontin and bone sialoprotein [10].

When using chitosan immobilized on a nanofiber membrane in complex with BMP-2 Park YY et al. (2006) obtained a significant osteoinductive effect [11].

During cystectomy with root apex resection and wisdom teeth extraction, chitosan methylpyrolidinone, which was obtained in the form of a sponge, was used to fill bone defects [4]. During histological and electromicroscopic examination of removed tissues, it was noted that its use promotes the growth of capillaries, perivascular tissues and stimulation of mesenchymal cells.

In vivo studies have confirmed that chitosan methylpyrolidinone is degraded by oral lysozyme. The formed chitosan oligomers activate macrophages and stimulate collagen formation. Monomers obtained from degradation are used to rebuild glucosaminoglycans in the extracellular matrix for bone repair. The osteoconductive properties of chitosan methylpyrolidinone have been confirmed in experiments on rabbits, which are similar to the processes described above in humans [6]. Modification of chitosan by introducing an imidazole group increased the cationic capacity of chitosan and increased its osteoinductive properties. The use of imidazole chitosan is much more effective than chitosan alone, and more effective than methylpyrolidinone, during cystectomy with root apex resection and wisdom teeth extraction [6].

M. Ito (1991), using hydroxyapatite powder and CaO and ZnO additives with a chitosan solution [12], obtained a rapidly hardening paste with high compression rates. It is possible to regulate the compression by changing the percentage of the components in the chitosan solution. The author notes the pronounced anti-inflammatory effect of the paste and the absence of migration of hydroxyapatite particles into the surrounding tissues.

R. Murugan, R. Ramakrishna (2004) used chitosan to increase the bioresorption of hydroxyapatite [13]. The hydroxyapatite-chitosan composite had good biocompatibility, bioresorbability, a pronounced hemostatic effect, high antibacterial activity, plasticity, and good adhesion. When processing carbonatapatite, a 5-10% chitosan solution was used. The IR spectra of the composite show characteristic peaks for carbonate apatite, while the structure of carbonate apatite is preserved. With an increase in the concentration of chitosan in solution, the bands at 603 and 571 cm – 1, which characterize the crystallinity of the structure, decrease. When studying the ratio between the content of Ca2 + and carbonate apatite-chitosan in the model solution, it was found that the higher the

concentration of chitosan, the higher the level of Ca2 +, with a decrease in the amount of chitosan, the content of Ca2 + decreases. However, the parameters of the crystal lattice of apatite carbonate after treatment with chitosan practically did not change. Investigation of pH under conditions of resorption of composites revealed that the higher the concentration of chitosan in carbonate apatite, the lower the pH. The pH level becomes unchanged at pH 7.1. The obtained nanocrystalline carbonate apatite from an aqueous solution at a low temperature with the addition of chitosan can be used to replace bone defects with the activation of bioresorption of apatite carbonate.

R. Murugan et al. (2005) used chitosan to treat bovine bone hydroxyapatite carbonate to improve solubility [14]. The authors noted that, depending on the concentration of chitosan in the solution, the rate of dissolution of hydroxyapatite carbonate in an isotonic solution increased. A decrease in the pH of the solution for hydroxyapatite carbonate with a high chitosan content (from pH 7.4 to pH 7.1 for 20 days) was observed, while with pure hydroxyapatite carbonate the pH decreased slightly. Studies of the diffraction pattern did not reveal changes in the crystal lattice of hydroxyapatite carbonate upon interaction with chitosan. It was shown on IR spectra that with an increase in the content of chitosan in solution, the crystallinity of the structure of hydroxyapatite carbonate decreases.

R. Tarsi et al. (1995) investigated the adsorption of S. mutans on the surface of hydroxyapatite granules in the presence of low molecular weight chitosan and its derivatives, N-carboxymethyl chitosan and imadazolyl chitosan [15]. Saliva with and without sucrose was used as a control. The authors showed that the treatment of hydroxyapatite granules with chitosan and its derivatives significantly reduces the adhesion of S. mutans. The presence of chitosan in toothpaste, chewing gum, and prophylactic mouthwash significantly reduces colonization of S. mutans on the hydroxyapatite surface. The arrest of the growth of pathogenic flora is explained agglutination of microbial bodies with chitosan. The agglutination mechanism is identical to the adhesion of erythrocytes by polycations. Due to the binding of chitosan to sugar receptors on the cell membrane, a bacteriostatic effect is provided [16].

Chitosan found application in surgical dentistry in the treatment of fractures, distraction osteogenesis, when it was introduced into the composition of calcium phosphate, sulfate cements [17], pastes with GA [18], with β-TCP [19]; treatment of osteomyelitis (Aimin et al. 1999), osteoporosis (Hi et al. 2007). All researchers noted a positive effect.

In maxillofacial implantology, when covering titanium implants, chitosan promoted accelerated osseointegration, reduced edema, and an inflammatory component [20,21].

Thus, a review of the literature indicates a significant interest in chitosan by foreign and domestic researchers.

In the world industry, the production of chitin and chitosan has commercial shellfish as a raw material base, but the volume of this production is limited by the volume of catch. Silk production is traditionally developed in Uzbekistan, and the waste of the pupae of the silkworm Bombyx mori is a raw material source for the isolation of a very valuable natural polysaccharide - chitin, the modification of which synthesizes a second, no less popular product - chitosan [22].

For the first time, on the basis of NICCP, a technology has been developed and production of this polymer has been mastered, there are approved specifications for "Chitosan from silkworm pupae", TSh 88.2-13: 2011, a trademark for chitosan Bombyx mori - "Chitosilk" has been obtained. Chitosan Bombyx mori is a low-toxic substance and by its action belongs to the V class of toxicity. In addition, the sensitivity of Bombyx mori chitosan to microorganisms St. saprofiticus, Str.pyogens, Ent.faecalis, Esch was studied for the first time. Coli LP, Esch. Coli LN, Prot.vulgaris, Klebsiella, Actinomycete in vitro [23]. It was revealed that chitosan has an effect on both gram-positive and gram-negative flora, which will make it possible to use it in dental practice.

Conclusions: The unique properties of chitosan (biocompatibility, bioresorbability,non-toxicity, antibacterial properties, hemostaticity) will be widely used in therapeutic, surgical and orthopedic dentistry. The use of Bombyx mori chitosan from local sources of raw materials will be in demand for the creation of bioactive coatings on dental implants in domestic dentistry.

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