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DENTAL OSTEOPLASTIC MATERIALS

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Abstract

Osteoplastic materials: description and properties

With complete or partial loss of teeth, atrophy of the bone tissue of the jaw often occurs. Bone thinning occurs if a long time has passed after the loss of teeth, during which there was no chewing load. Atrophy occurs with varying intensity. It can also be caused by age-related changes and individual characteristics.

In such cases, restoration of the patient's bone tissue is necessary for successful implantation. It is carried out by using osteoplastic materials of biological or synthetic origin, which serve as a biomatrix for building a person's own bone: Over time, they are replaced by bone cells and form a platform for the installation of implants.

The need for bone regeneration is determined by the dental surgeon after examinations. If it is obvious in the picture that the patient's jaw bone has thinned so much that it is impossible to install an implant, the doctor recommends an osteoplasty operation and restore the lost volume of bone tissue.

There are two most common methods of osteoplasty:

• sinus lifting (an increase in the volume of bone tissue in the area of the bottom of the maxillary sinus);

• directed bone regeneration (NCR), which is performed using dental membranes in the area of the alveolar process.

So, osteoplastic materials are designed to form the patient's own bone tissue. To achieve this goal, they must have a number of basic properties, which we will discuss below.

Osteoinduction is the stimulation of the transformation of undifferentiated mesenchymal cells into osteoblasts. That is, the transformation of the body's own cells into bone tissue.

Osteoconduction is the main function of osteoplastic materials, which consists in creating a matrix (framework) for colonization of the body's own cells during the formation of bone tissue.

Biocompatibility is the body's acceptance of embedded materials, not their rejection.

Osteoprotection is the properties of osteoplastic materials similar to natural bone material, such as density and hardness.

Sterility is a necessary condition for the engraftment of the material, otherwise there is a high probability of its rejection. That is, osteoplastic materials should be free of bacteria and microorganisms. To do this, they are subjected to special sterilization, provided that the basic properties are preserved.

Porosity is a necessary property for the "ingrowth" of body cells into granules of the embedded material.

What is osteogenesis?

Osteogenesis is, in fact, the process of bone formation. It would seem that everything is simple, but after the operation for the addition of osteoplastic materials, osteogenesis occurs in several complex, albeit not visible to the eye, stages. Let's talk about them in more detail.

1. The phase of clot formation, which occurs immediately after the completion of the operation. Platelets form into conglomerates that stop bleeding from damaged vessels, fibrin filaments are formed. This hemostatic phase ends with the formation of an elastic clot.

2. The phase of inflammation is the most painful phase, which lasts differently in different patients, but in the process, cleansing of the wound surface is extremely important for the engraftment of the embedded tissue. Exudate is released through the vascular wall, granulocytes are released from the bloodstream. Granulocytes migrate through the clot, settle on the bone walls and clean the wound through phagocytosis.

3. The phase of formation of new cells (angiogenesis), during which vascular branches appear in the additive zone between the tissues, feeding the damaged area. Fibroblasts and undifferentiated blast cells migrate through these vessels.

4. The polypheration phase is characterized by the formation of connective tissue from fibroblasts. At the same time, undifferentiated blast cells divide under the influence of signaling proteins. This creates a new tissue permeated with collagen fibers. Then osteoblasts ("builder cells") are formed from these cells, which produce osteoid (adhesive substance). At the end of the polypheration stage, the osteoid is mineralized with the help of calcium and phosphate compounds, resulting in the formation of immature bone tissue.

5. The phase of bone tissue remodeling – that is, the renewal of its spongy layer and the formation of new, well-structured bone tissue. At this stage, osteoblasts literally destroy channels in immature bone by chemotaxis. A network of vessels feeding bone tissue begins to develop, and osteoblasts are transformed into osteocytes and fixed in the newly formed bone. This bone tissue is able to withstand chewing load.

The above-mentioned phases of osteogenesis, as we said earlier, take different time in different patients. The duration depends on the size of the defect, the type of membrane used (if used), the amount of material to be attached and the physiological characteristics of the patient. However, most often the phases from the first to the fourth are completed within four months from the moment of osteoplasty, and the last, fifth, can last from six months to eight months.

Types of osteoplastic materials

By origin, osteoplastic materials are divided into the following key groups:

• autogenic (the patient is the donor);
• allogeneic (the donor is another person);
• biological (animal donor);
• synthetic (produced in laboratories, most often from materials based on calcium salts).

Let's talk in more detail about each of these types.

Autogenic osteoplastic materials

The patient's own bone is usually taken from donor areas in the oral cavity, such as:

• angle of the lower jaw (in the area of the outer oblique line);
• retromolar region of the mandible;
• chin symphysis;
• the tubercle of the upper jaw, etc.

The manipulations are performed under local anesthesia and take a short time.

Types of autogenic osteoplastic materials by bone type:

• cortical;
• spongy;
• spongiocortical.

The property of maximum osteogenesis is characteristic primarily for the spongy type due to the large number of active vital cells. When using this type of autograft, rapid regeneration of bone tissue is ensured.

However, in cases where it is required to obtain a significant amount of bone tissue, autostomy is performed from areas such as the ilium, tibia, ribs and cranial vault, etc. This operation is performed under general anesthesia and is, of course, more traumatic for the patient and labor-intensive for the doctor.

With any of the methods used, doctors use a bone scraper and a bone mill to collect autogenic material. These are special tools for obtaining and grinding the patient's bone tissue.

The most modern and less traumatic method of removing auto–resistance is using a piezo device. Ultrasound technology is used in the operation of these devices, which causes the tip of the device to vibrate. This method greatly simplifies and speeds up the procedure for obtaining an autograft.

Piezo devices can also be used by dental surgeons for other work, as they have a lot of functions. Piezo devices from various countries of production are presented on the Russian market in a wide price range. Traditionally, the South Korean piezo devices Sonic Surgeon from Dong Il Technologies demonstrate an attractive price with excellent quality.

Autogenic osteoplastic materials, in addition to osteoconduction and osteoinduction, provide direct osteogenesis. Thus, new bone tissue of the highest quality is formed faster. When using autogenic material, the risk of rejection is minimized and the most predictable results of transplantation are achieved, which has been proven by clinical studies.

At the same time, it is important to take into account the negative aspects of using the autotransplantation method:

- the need for additional surgical intervention in several areas;
- the possibility of infection during material collection;
- risk of nerve damage at the site of intervention;
- soreness and duration of healing of wounds outside the oral cavity;
- accelerated resorption and volume loss in the long term.

Taking into account the above negative factors, autogenous transplants are mainly used in conjunction with other materials of biological or synthetic origin.

Allogeneic osteoplastic materials

This type of bone graft is obtained from cadaverous human bones by grinding to a size of 300-450 microns and demineralization, lyopholization, and, if necessary, irradiation with gamma rays. Demineralization is the process of cleansing bone tissue

from salts and minerals to achieve maximum elasticity. And lyophilization is vacuum drying to enable long-term storage of the material and transportation.

According to the composition, allogeneic grafts are divided into:

• native, when the structure of the tissue is preserved, while the content of organic and mineral components is homogeneous;

• deproteinized - in the form of a hydroxyappatite crystal lattice after protein deactivation (only minerals remain in the composition);

• demineralized, which, on the contrary, contain only organic components after processing.

Allogeneic osteoplastic materials have a number of advantages:

• the ability to osteoinduce;

• non-traumatic receipt of the material and reduction of time for surgery;

• high adhesion to the patient's tissues;

• increased microporosity to achieve accelerated osteogenesis.

Despite these advantages, allogeneic transplants also have disadvantages, such as the risk of immune reactions in the patient and the unpredictability of the result.

Biological osteoplastic materials

This type of material is obtained from animal bone tissue by heat treatment and enzyme purification.

After purification, the biological osteoplastic material contains no cells of the donor body, all proteins and microflora, but the natural structure remains. When using it, the

isk of rejection is minimized. After performing the function of bone synthesis, biological grafts partially dissolve under the influence of the patient's cells.

Biological osteoplastic materials are also called xenogenic.

Cows, pigs and horses are most often donors for the manufacture of xeno materials. Pork bone material is used most often due to its low cost, availability and effectiveness.

Its advantages:

• biocompatibility and high biological activity;

• hydrophilicity and permeability;

• protection from mad cow disease or Creutzfeld-Jakob disease due to maximum cleaning;

• preservation of the original structure with complete removal of organic substances and ensuring complete safety of the material due to low-temperature sintering;

• a structure as similar as possible to the structure of human spongy bone tissue (high porosity - more than 76%);

• the ability to maintain the shape of the surface due to special processing technology.

Synthetic osteoplastic materials

Laboratories around the world have been actively working for more than 40 years to create a kind of matrix for the patient's future bone. And, it should be said, the work is not unsuccessful. The prototypes of modern synthetic osteoplastic materials, which are mainly created from calcium phosphates and tricalcium phosphates, bio-glass, calcium sulfate, chondrotin sulfate, previously served as corals and algae.

Synthetic materials have the following advantages:

• Accessibility and cost-effectiveness;
• Security;
• biocompatibility and minimal risk of complications.

Most often, dentists use this type of transplant in combination with biological bone material, which is an alternative to the use of autotransplantation.

Currently, the most common osteoplastic materials are beta-tricalcium phosphate and hydroxyapatite.

Let's consider the composition and properties of synthetic bone materials using the example of the products of the South Korean manufacturer Dentis, which is represented on the Russian market by the company IdepenDENTpro.

• Ovis Bone HA, which is 100% hydroxyapatite (calcium phosphate, similar in composition and structure to human bone);

Ovis Bone BCP, consisting of 80% beta-tricalcium phosphate and 20% hydroxyapatite. Beta-tricalcium phosphate is rapidly resorbed, while due to ion exchange on its surface, osteoblasts spread and adhere. Hydroxyapatite performs a skeleton function.

Synthetic osteoplastic materials have many advantages:

• variability of structure depending on the clinical case (large and small pores);
• radiopacity;
• high hydrophilicity;
• optimal integration into bone tissue;
• Biocompatibility and biological activity;
• Ease of use;
• a comfortable price.

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