OSTEOINTEGRATION IN DENTAL IMPLANTS

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Abstract. The popularity of orthopedic treatment using the method of dental implantation causes the interest of researchers to study the integration of implants in bone tissue. Analysis of the literature shows that the improvement of research technology and interdisciplinary approach to the study of the phenomenon of osteointegration of dental implants has led to a change in traditional concept in recent years. This article summarizes information about the physiological processes and cellular interactions occurring on the border "implant-bone tissue" in various stages of integration. The results of studies indicate the need for revision notions of bio inertness of titanium implants and consideration of the integration process in the immunological aspect.

Keywords: osteointegration, dental implantation, osteoblast, bone regeneration, contact osteogenesis.

Introduction: Osteointegration of dental implants refers to the process of bone growing right up to the implant surface. No soft tissue connects the bone to the surface of the implant. No scar tissue, cartilage or ligament fibers are present between the bones and implant surface. The direct contact of bone and implant surface can be very fied microscopically. When osteointegration occurs, the implant is tightly held in place by the bone. The process typically takes four to six months to occur well enough for the implant dentist to complete the restorations. This article provides a comprehensive review of osteointegration in dental implants.

Today, dental implantation is successfully used for orthopedic rehabilitation of patients with various types of dental defects. The relevance of this method of dental treatment is dictated by the high prevalence of partial and complete absence of teeth and the need for patients to effectively restore the integrity of the dental system in the conditions of increasing requirements for aesthetics and comfort. The world experience of using prosthetics based on dental implants demonstrates the ability to use this method in various clinical situations (both for fixed prosthetics and for improving the fixation of removable structures) and at the same time achieve predicted success in treatment.

The steady growth in the popularity of dental implantation in recent decades has led to an increasing interest of researchers in studying the mechanisms of implant integration in bone tissue. Traditionally, the most favorable way of integration is considered to be osteointegration, which Per-Ingvar Branemark, the founder of modern dental implantology, defined as "obvious direct (direct) attachment or attachment of living bone tissue to the implant surface without introducing a layer of connective tissue". Its achievement is considered a necessary condition for the success of prosthetics based on implants in the long term.

The phenomenon of osteointegration was discovered by p.-I. Branemark accidentally, when studying microcirculation in bone tissue using a small optical camera surgically implanted in the tibia of a rabbit. Over the four decades following this discovery, an extensive scientific database describing the mechanisms of implant integration in bone tissue has been accumulated and continues to be updated.

A. Kulakov et al. (2012) proposes to consider the integration of the implant into the bone tissue as a dynamic process of interaction between the living and non-living, provided that the balance of compensatory and homeostatic mechanisms is reached, which allows the living and the dead to coexist in a single system. The criteria for the success of this interaction are the absence of inflammatory, necrotic and allergic processes in peri-implant tissues, i.e. the absence of rejection reactions; formation of morphofunctional determinants of the integration process in the zone of contact between the implant and the surrounding tissue (in the case of dental implantation - osteoid or bone substance); relative stability of these determinants over time.

According to the literature, there are the following ways of organizing tissues at the implant/bone border:

- osteointegration, as defined by p. I. Branemark , is the direct contact of the bone with the implant surface;
- fibroosteointegration implies the presence of a connective tissue layer between the actual bone and the implant, consisting of collagen-new fibers and coarse-fiber connective tissue;
- connective tissue integration that occurs when the implant surface is surrounded by fibrous connective tissue.

In the literature, the first two options are described as the normal reaction of the bone to implant insertion, and the latter is considered as its rejection.

For a long time, the generally accepted theory of osteointegration remains the blood clot retraction theory.

According to this theory, the first phase of the osteointegration process is osteoconduction, the essence of which is reduced to migration and adhesion of mesenchymal cells and osteoblasts to the implant surface through the remainder of the blood clot. The second phase, osteoinduction, involves the direct formation of bone, the deposition of mineral salts in the newly formed bone matrix. The final stage of bone regeneration around the implant is remodeling , which is a long process of restructuring consisting of alternating cycles of resorption and bone formation.

Insertion of the implant into the bone is a surgical trauma for the tissue, which results in inflammation, initial manifestations of resorption, and a cascade of vascular-tissue reactions with subsequent regeneration. An important role in this process is played by the state of the vascular bed and the level of blood supply in the area of damage. In conditions of ischemia there is a tendency to form fibrous and cartilaginous tissues instead of forming bone structures.

It was found that even when the implant is twisted at high speeds and good primary stability is achieved during the positioning of the implant, there is a gap of up to 60 microns between it and the surrounding bone. Depending on the degree of trauma of the operation in the future, it may increase to 100-500 microns in some areas. This space is filled with blood and tissue fluid, which are sources of biologically active substances and proteins necessary for initiating the process of osteointegration of the implant. Although different properties of the implant surface can affect the composition and conformation of binding proteins, cell membrane receptors interact with the titanium surface, and eventually the initial attachment of cell elements to it occurs.

At the initial stage of osteointegration, the extracellular protein fibronectin and transmembrane heterodimers - integrins take an active part in the recognition and adhesion of cells on the implant surface.

Blood from the vessels of the implant's bone bed forms a clot that includes platelets, fibrin, vascular growth factors, transforming growth factor, insulin-like growth factor, etc. These components stimulate the formation of new blood vessels and the healing of bone tissue.

The network of fibrin fibers allows the migration of osteogenic cells under the influence of growth factors synthesized by platelets to the implant surface. Growth factors attract fibroblasts and other undifferentiated cells to the zone of the fibrin matrix, and also stimulate their differentiation.

The peculiarities of this stage largely determine the further integration of the implant. The dense attachment of a blood clot to the implant surface and the formation of fibrin "bridges" between it and the viable bone create conditions for the proliferation of osteogenic cells along the fibrin filaments towards the implant and the formation of de novo bone on the surface of the implant itself contact osteogenesis, the main mechanism of osteointegration.

Given the importance of the area and density of attachment of blood components and bone elements to the implant surface at the initial stages of the integrative process, the need for a developed topography and micro-relief of the surface of the intraosseous part of the dental implant is not in doubt today. To create a complex surface topography with optimal roughness indicators, various processing methods are used, which can be divided into two basic approaches:

1) treatment of the implant surface using physical or chemical factors (sandblasting, acid etching, laser treatment, etc.);

2) deposition on the surface of biologically active components that stimulate bone formation (hydroxyapatite, tricalcium phosphate, amino acids, etc).

However, the integration of the implant only through contact osteogenesis seems to be a kind of ideal model. Most likely, the processes of contact and distant osteogenesis occur in parallel on different parts of the bone - implant interface. In this case, the latter is characterized by the formation of bone tissue not on the surface of the dental implant, but on the surface of the surrounding bone. Osteogenic cells of the implant bed produce a bone matrix in the direction of the implant surface.

The attachment of osteoblasts to the implant surface is observed in the first days after its installation. Osteoblasts synthesize a number of proteins that are markers of osteogenesis, such as osteopontin, osteocalcin, and sialoprotein, which promote the adhesion of osteogenic cells on the implant surface, as well as the consolidation of mineral compounds in the newly formed organic matrix of the bone. Then begins the construction of a collagen matrix directly on the surface of the implant, the deposition of osteoid substance, which later transforms into bone.

Bone mineralization is associated with the accumulation of calcium and phosphorus ions in the newly formed bone matrix, and in addition to calcium-binding proteins, phospholipids and chondroitin sulfate of the main substance participate in it.

Young bone tissue is then subjected to a long-term structural adjustment. This stage, bone remodeling, combines two multidirectional processes-bone resorption and new bone formation.

Immature bone resorption occurs primarily as a result of matrix metalloproteinases secreted by osteoclasts. At the same time, there is an increase in the activity of the acid phosphatase enzyme. The construction of a new bone in the direction of the implant surface is due to the high functional activity of osteoblastic cells and is accompanied by the expression of alkaline phosphotase.

The remodeling process is closely related to the load conditions of the implant and as a result leads to the replacement of immature bone tissue with a functionally more complete structure. The result of structural adjustment is the connection of the newly formed bone with the surrounding spongy substance.

Interdisciplinary research in immunology and implantology over the past two decades has significantly enriched and deepened the understanding of the mechanisms of reparative regeneration of bone tissue, including in implantation. In 2012, the results of the work of L. Chen and K. Rahme were published, showing the ability of titanium to form nanoparticles in water at room temperature.

There is a growing number of publications reflecting changes in the receptor apparatus of immune system cells as a result of exposure to metal nanoparticles. It is experimentally established that particles of titanium, iron, and silicon oxides can undergo phagocytosis. This study, as well as a number of publications demonstrate the need to consider metal alloys not from the point of view of "bio-inertness", but from the point of view of their immunological compatibility with body tissues.

Based on foreign and own research, V. V. Labis, E. A. Bazikyan (2016) showed that there is an emission of nanoscale particles from the oxide layer of the surface of dental implants of various manufacturers (Nobel Replace, Astra Tech, Straumann, MIS, Alfa - Bio, etc.). Forming conjugates with plasma proteins, these nanoparticles are then presented to immunocompetent cells. Interactions of cells in perimplant tissues further determine the adaptive immune response, which is assigned a regulatory function in determining the course of reparative osteogenesis.

The authors also proposed a method for testing activation of peripheral blood basophils by metal nanoparticle supernatants from the surface of the dental implant, which will allow selecting the implant system in each clinical case based on the individual sensitivity of the patient to a particular material.

Immunocompetent cells play an important role in regulating the process of osteointegration at different stages. Interleukins, chemokines, and tumor necrosis factor synthesized by myeloid cells are involved in regulating the interactions of cells and intercellular substance with the implant surface and stimulate angiogenesis.

During the migration of lymphocytes in the collagen matrix, a selective group of cells accumulates that can influence the proliferation of fibroblasts and the secretion of collagen proteins.

Reparative regeneration of bone tissue around the implant is a complex multi-stage process, which involves coordination of not only local cellular elements and signaling molecules. The regulatory function is also performed with the participation of the nervous and endocrine systems, whose action is realized through such biologically active substances as serotonin, P-endorphin, etc.

Many studies have been devoted to the objective evaluation of implant osseointegration parameters. A group of scientists with the participation of Dr. T. Albrektsson conducted a morphological study of 33 extracted osteointegrated implants of the Nobel Pharma system. During the work, an average of 70-80% of bone contacts with the implant surface were detected throughout the entire interface. According to the authors, for reliable osseointegration of the implant, it is necessary that at least 60% of the periimplantation density is bone substance.

Professor T. Albrektsson, a representative of the Swedish implantology school, who worked on the problem of osteointegration together with P.-I. Branemark, named the main factors that affect the integration process:

- the material from which the implant is made;
- design of the implant;
- the surface quality of the implant;
- load conditions;
- surgical technique for implant placement;
- condition of the bone tissue around the implant.

In various domestic and foreign publications, you can find other factors, but on closer examination, their essence is reduced to the above. In recent decades, work on improving the technique of dental implantation is aimed at optimizing the process in these six areas.

Conclusions: Thus, a large number of studies conducted in this direction indicates the high relevance of the problem of osteointegration and a consistently high interest of dentists in finding ways to achieve the predicted success in dental implantation. New horizons are opening up in the study of implant integration into bone tissue using an interdisciplinary approach to the problem. It seems that the disclosure of immune, humoral and neural mechanisms of regulation of the integration process will create additional opportunities for targeted impact on them and will make dental implantation an even more predictable and effective method.

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