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Research Article

Anatomical and Functional Considerations about Dental Implants. Part I: Biology and Osseointegration

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Abstract

Introduction: Bones are highly dynamic plastic structures that are constantly renewing, remodeling and adapting to the different conditions to which they are subjected throughout their life. Oral rehabilitation with osseo-integrated implants requires integrated planning essential for successful treatment. There are some important biological and mechanical aspects to be considered in relation to rehabilitation with implant systems.

Objective: To perform a literature review to describe important biological biomechanical aspects to be considered in relation to oral rehabilitation with dental implants.

Methodology: The research was carried out in five databases (PubMed, Cochrane Library, Lilacs, Scielo, and Google Scholar) using the variation of the search terms “Anatomy” and “Dental implants”, retrieving 1003 publications.

Results: After reading the titles and abstracts, 91 texts were conducted for full reading and 18 publications were considered for data extraction and article synthesis.

Conclusion: the knowledge of the quality of bone tissue and biological aspects is important for the Dental Surgeon to recover the aesthetics and functionality of the stomatognathic and phonetic system, providing a better quality of life to patients.

Keywords: Dental Implants; Biocompatible Materials; Anatomy

Introduction

One of the main objectives of rehabilitation treatment by means of osseointegrated implants is to preserve the integrity of the noble intraoral structures, restoring the aesthetics and functionality of the stomatognathic and phonetic system, enabling a better quality of life for patients [1]. Oral rehabilitation with osseo-integrated implants requires integrated planning essential for successful treatment [2].

Osseointegrated implants began to be developed in 1956 and were clinically evaluated in the late 1960 [3]. Through a study of blood micro-circulation with a titanium observation camera, inserted in rabbit tibias. It was observed that the metal and bone were integrated and there was no rejection by the animal's organism. According to Branemark, osseo-integration is defined as a direct structural and functional connection between the living, ordered bone, and the surface of an implant subjected to functional load. The advent of osseo-integrated implantology has caused, in the last thirty years, a dramatic change to the therapeutic possibilities of partially or totally edentulous patients, notable improvement in the results - not only functional, but also aesthetic - and in the long-term prognosis, results achieved [4].

However, there are some important biological and mechanical aspects to be considered in relation to oral rehabilitation with implant systems. These being determinants for the osseo-integration process. Thus, the aim of this study was to describe important biological aspects to be considered in relation to oral rehabilitation with dental implants.

Bone tissue is a specialized form of connective tissue composed of three basic cell types: osteocytes, osteoblasts and osteoclasts. Due to the presence of a mineralized, calcified bone matrix and layers of bundles of type I collagen (85%), type III and V collagen (5%) and Hydroxyapatite arranged in an organized way, it is a more rigid and resistant tissue. When the tissue is considered lamellar, it can be classified according to its structural organization: cortical (compact) and trabecular or medullary (spongy). The cortical bone has a higher density and less porosity than the trabecular bone due to the fact that the cortical bone has approximately 80% to 90% of calcified volume and the trabecular bone, approximately 15% to 25% [5,6]. Cortical bone plays the role of support and protection and undergoes less remodeling, whereas trabecular bone has a greater metabolic capacity and greater remodeling activity, remodeling faster than cortical bone. This remodeling also allows the bone to function as a calcium reservoir. Towards the long axis of the cortical bone are the harvers channels and perpendicularly along the long axis, the Volkmann channels, through which vessels and nerves pass [7].

Lekholm and Zarb proposed a classification, which assesses the relative proportion of cortical and trabecular bone: Type 1, homogeneous compact bone; Type 2, bone with a thin layer of compact bone around a core of dense trabecular bone; Type 3, bone with a thin layer of cortical bone around dense trabecular bone, with favorable resistance; Type 4, bone with a thin layer of cortical bone, with a low density trabecular bone core [3].

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Type 2 bone is considered by many authors to be the ideal type of bone for implant placement, due to the considerable thickness of the cortical bone that allows good primary stability and the trabecular bone that has greater vascularity, compared to type 1. The bone type 2 is more characteristic in the anterior region of the jaw (66%), followed by the posterior region (50%). In the maxilla, type 3 bone is considered the most prevalent in the anterior region (65%), followed by the posterior region (50%) [8].

Despite an apparently inert aspect, the bones are highly dynamic plastic structures that throughout the life of the organism are in constant renovation, remodeling and adaptation to the different conditions to which it is subjected and this sequence of facts is known as bone plasticity [5].

After surgical preparation at the bone-implant interface, the formation of the blood clot and its retention on the implant surface are considered a prerequisite for bone integration. Through a fibrin network, osteogenic mesenchymal cells, after implant installation, migrate towards the implant surface, colonizing it quickly and differentiating into odontoblasts, which will be responsible for producing an organic bone matrix that will mineralize. After this calcification of the osseo matrix, regulated by proteins and enzymes, mainly alkaline phosphatase, odontoblasts are attached to the matrix, maturing into osteocytes, forming the new bone quickly and allowing the biological fixation of the implant, ensuring tissue anchorage when presenting a wider medullary space [9].

Once the initial bone formation has occurred, under the load stimulus in the implant, bone remodeling will occur and the newly formed bone will be gradually replaced by lamellar (mature) bone, with greater resistance to masticatory forces. This remodeling process is of fundamental importance for the secondary stability of the implant in the long term, and initially they are mainly influenced by the biomechanical stability of the implant at the healing site [10].

To correct extensive bone resorption for the purpose of rehabilitation with implants, it is necessary to use bone graft surgical techniques [11]. As for the origin, biomaterials can be divided into: 1) Autologous (autogenous): Biomaterial obtained from the patient himself; 2) Allogenous/Homologous (allograft): Obtained from beings of the same species; 3) Xenogen/Heterologist (xenograft): Biomaterial obtained from other species and (4) Alloplastic: Inorganic (mineral origin) or synthetic materials [12]. To increase the vestibulolingual thickness between the alveolar ridge and the important noble anatomical structures, the autogenous bone graft is the most indicated [13].

Among the intraoral areas most used as bone tissue donors, the chin and the oblique line in the jaw and, in the maxilla, the tuberosity are indicated [11]. There are other types of surgical interventions applied to implantology, such as lifting of the maxillary sinus mucosa and lateralization of the lower alveolar nerve [14].

The biological mechanisms/phenomena of bone growth/regeneration with the use of grafts can occur by osteoconduction, osteoinduction and osteogenesis. Osseopromotors have membranes (Geistlich Bio-Gide®) or barriers, with selective permeability or not. Osteoconduction works as a framework that will support neoformation and bone growth. The inorganic matrix favors the proliferation of osteoprogenitor cells and subsequent apposition of new bone tissue. The biomaterials that represent these characteristics are autogenous, allografts (Homogeneous), alloplastic, heterogeneous (heterologous) and require a bone bed [12].

Osteoinduction stimulates the recruitment and differentiation of mesenchymal cells into osteoprogenitor cells. Remodeling occurs through osteoclastic activity, cell differentiation and the production of new bone. It is the formation of new bone from osteoprogenitor cells, derived from mesenchymal cells. As an example we have the biomaterials of Leukoplakelet Aggregates (L-PRF), bone morphogenetic protein 1, 2 (BMP-1, 2) and autogenous bone. Osteogenesis is achieved by viable transplanted cells (osteoblasts and osteoprogenitors). Being autogenous bone, the only material with osteogenic properties. Promotes rapid tissue repair, absence of immune response and cross-infection between donor and recipient. Bone morphogenetic protein (BMP), which is commonly found in bone, is considered to be primarily responsible for osteoblast activation [12].

Thus, bone neoformation depends on some determining factors such as stability of the interface, vascularization, bone-forming cells, osteoinductive factors (BMP, PRF) and the support framework to promote osteoconduction [13].

Methodology

The research in five databases (PubMed, Cochrane Library, Lilacs, Scielo and Google Scholar) was carried out by two independent reviewers in order to describe important biological, anatomical and biomechanical aspects to be considered in relation to oral rehabilitation with implants dental. With the following eligibility criteria:

Inclusion criteria: 1) Publications or books that describe anatomical aspects of the maxilla and jaw applied to implantology 2) Report complications in oral rehabilitation with bone-integrable implants. 3) Expose generalities of bone tissue, bone integration process and grafts.

Exclusion criteria: 1) publications where the terms applied anatomy and dental implants appear only in the authors' affiliation or in the references. 2) Publications that do not directly discuss the central objective of the topic.

The titles of all stored publications were read, and, when necessary, the summary, introduction and/or results and discussion sections were carefully investigated to ensure that the publications met the eligibility criteria. After the screening of the two independent reviewers, disagreements were discussed and resolved by consensus.

Results and Discussion

18 publications were selected to prepare the synthesis of this article after applying the selection method. Initially, duplicates were excluded (n = 27), the electronic search procedure recovered 1003 publications. After reading the titles and abstracts, 912 were excluded (they did not directly discuss the central objective of the theme: n = 332; the terms Anatomy and Implantology were only included in the authors' affiliation or in the publication references: n = 580) and 91 texts were conducted for full reading.

From the selected publications, 7 (38.9%) original articles, 6 (33.3%) book chapters, 4 (22.2%) review articles and 1 (5.6%) Case report. Among the publications, laboratory work and clinical trials were the most found (9; 50.0%). General aspects about the anatomical-histological description of bone tissue and donor areas for grafts were also found (5; 27.8%). Another 4 (22.2%) publications reported the importance of anatomical knowledge of related areas and possible complications in oral rehabilitation with implants.

Bone remodeling allows the replacement of immature bone in lamellar bone and involves the processes of bone resorption and formation (apposition), aiming at maturation and consequent improvement in tissue quality. The activity of bone tissue formation is always associated with bone resorption, initiated by osteoclasts, which after its activation causes bone resorption and with the activation of osteoblasts the formation of new bone tissue occurs [10].

The bone remodeling cycle begins with the recruitment of pre-osteoclasts (hematopoietic origin) to the resorption site and differentiates into active osteoclasts and begins resorption with the secretion of acidic and hydrolytic enzymes degrading the organic and inorganic components of the bone matrix, forming a resorption gap. After the apoptosis suffered by osteoclasts, recruitment of pre-osteoblasts (mesenchymal origin) occurs, stimulated by the presence of the Transforming Growth Factor beta (TGF-b) and Bone Morphogenetic Proteins (BMP's), released in the process of resorption. Pre-osteoblasts differ in osteoblasts and occupy the resorption gap, secreting bone organic matrix that will later be mineralized. After bone matrix mineralization, osteoblasts are trapped and differentiate into osteocytes [6,10].

Osseo-integration presents predictable, reproducible and stable results over time, with success levels close to 90% [15,16]. However, like any technique, it is subject to failure. The occurrence of complications is inherent to any surgical procedure; Among the various factors that contribute to the failure of osseo-integrated implants, we can highlight the systemic condition of the patient, decreased healing capacity, bone quality, smoking, the experience and skill of the professional, the use of inappropriate surgical techniques, excessive surgical trauma, incorrect use of antibiotics, mechanical trauma during healing, bacterial infection, inadequate planning, occlusal overload and harmful parafunctional activities [17,18].

Therefore, a routine of care is necessary in relation to oral hygiene, healthy habits and regular monitoring by the dentist (routine consultations).

Conclusion

Therefore, knowledge of the quality of bone tissue, biological and biomechanical aspects, is important for the Dental Surgeon who will develop in implantology and advanced surgeries applied to the specialty in relation to oral rehabilitation, in order to recover the aesthetics and the functionality of the stomatognathic and phonetic system, providing a better quality of life to patients.

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