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Dental balance in the arcs for the implants: a concise systematic review

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Abstract

The teeth together perform the functions of mastication, protection, and support of related soft tissues, help in the articulation of words, and are an important factor in the aesthetics of the face. The macro geometry of the implant provides influences on osseointegration. In this sense, the various isolated characteristics (thread type, thread pitch, thread depth, face angle) must be studied so that the implant geometry can balance the compressive stress and tensile stress and produce a minimum shear force. The present study aimed to carry out a concise systematic review of the main considerations of dental balance in the arches in implant dentistry. Thus, knowledge of the direction of the teeth is of great importance in clinical implant dentistry for the correct installation of implants, which are very important for maintaining the balance of forces exerted by masticatory muscles (masseter muscle, temporal muscle, medial pterygoid muscle). In addition to this, the evaluation of the amount and density of bone available in the patient's edentulous site. It was concluded that the optimized aesthetic positioning of the implant presents numerous factors for the good aesthetic performance of an implant-supported prosthesis. The main conditions of the soft tissues, the amount of bone, and the location and inclination of the placed implant can be cited as the main ones. The correct positioning of the implant is linked to the location and axial inclination of the implant, aiming to favor the emergence profile and aesthetic contours of the prosthesis. The ideal location for the implant would be the one assumed by the lost tooth root. Also, the location of the height of the cervical portion of this implant concerning the adjacent teeth is important for determining the prosthetic space available for making the restoration, as well as its emergence profile and the biological space of the surrounding soft tissues.

Keywords: Dental implants. Balance. Dental Arch. Implant geometry.

Introduction

Oral rehabilitation with osseointegrated implants has very high success rates [1-3]. The biomechanical behavior of dental implants is different from natural teeth because they do not have a periodontal ligament; in this way, they transmit masticatory loads directly to the supporting bone. This characteristic of distributing loads directly to the bone tissue results in the modification of tissues adjacent to the implant. The bone tissue undergoes a modification to establish new biological distances, of which bone resorption is part [3,4].

In this regard, the macro geometry of the implant influences osseointegration. In this sense, the various isolated characteristics (thread type, thread pitch, thread depth, face angle) must be studied so that the implant geometry can balance the compressive stress and tensile stress and produce a minimum shear force [5].

In this sense, the emergence and application of the principles of osseointegration in dentistry enabled new horizons for the oral rehabilitation of partial and total edentulous patients [6-8]. Suggested by several researchers and later studied by Brånemark [9].

Currently, after decades of in vitro and in vivo experimental studies, osseointegrated dental implants have reached a stage of scientific proof that enables their use in oral rehabilitation, with expressive success rates verified in the most varied restorative situations [10,11].

Although the survival rate for dental implants has been reported to be more than 90%, compromised bone conditions promote implant failure and jeopardize today's high success rates. The main concern is related to the aging of the population. Diabetes, osteoporosis, obesity, and drug use are medical conditions that can hinder bone healing around dental implants [12].

In this scenario, the great advance in dentistry linked to the emergence of osseointegrated implants is based on the possibility of producing support for prosthetic restorations in areas where there are no dental elements or residual roots [13]. This undoubtedly generated a unique opportunity to improve the aesthetic-functional performance of patients who, due to the absence or unfavorable distribution of dental elements, had removable partial or complete dentures as their only restorative alternative. In addition to these, other partial edentulous patients, such as cases of single edentulism, can also benefit from osseointegrated implants when it becomes unnecessary to use remaining teeth, often healthy, as support for prosthetic restorations, eliminating tissue removal. healthy dentary [14].

Clinical research on several osseointegrated implant systems published in the dental literature has shown that the longitudinal success rates of implants increase proportionally to the development of new components and surgical-restorative techniques, which justifies their gradual increase in clinical application in oral rehabilitation [15,16].

Therefore, the present study aimed to carry out a concise systematic review of the main considerations of dental balance in the arches in implant dentistry.

Methods

Study Design

This was followed by a systematic literature review model on the main clinical findings of mandible fractures, according to the PRISMA rules.

Data Sources and Research Strategy

The literary search process was carried out from February to March 2023 and was developed based on Scopus, PubMed, Science Direct, Scielo, and Google Scholar, using scientific articles from 2009 to 2022, using the descriptors (MeSH Terms): *Dental implants. Balance. Dental Arch. Implant geometry,* and using the Booleans "and" between the descriptors (MeSH Terms) and "or" between the historical findings.

Study Quality and Risk of Bias

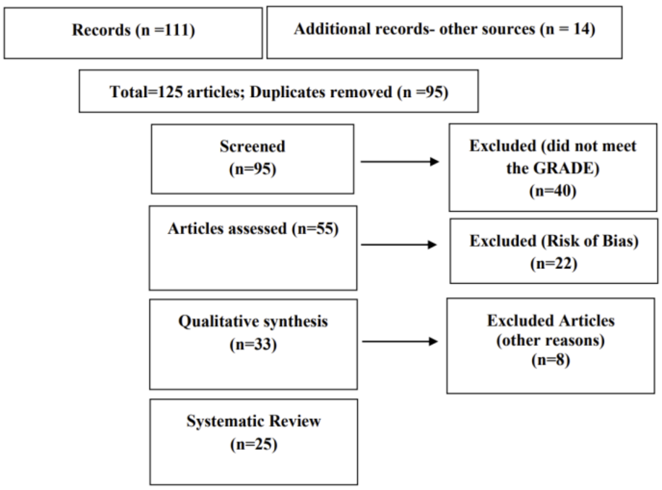
The quality of the studies was based on the GRADE instrument, with randomized controlled clinical studies, prospective controlled clinical studies, and studies of systematic review and meta-analysis listed as the studies with the greatest scientific evidence. The risk of bias was analyzed according to the Cochrane instrument.

Results and Discussion

Summary

A total of 125 articles were found. Initially, duplication of articles was excluded. After this process, the abstracts were evaluated and a new exclusion was performed, removing the articles that did not include the theme of this article, resulting in 55 articles. A total of 33 articles were evaluated and 25 were included and developed in this systematic review study (Figure 1). Considering the Cochrane tool for risk of bias, the overall assessment resulted in 22 studies with a high risk of bias and 40 studies that did not meet GRADE.

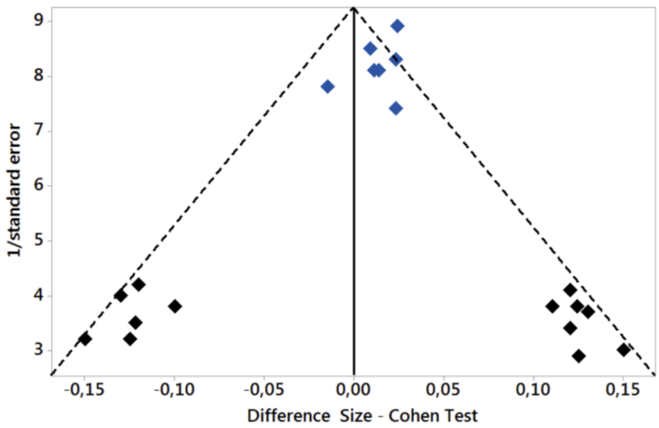
Figure 1. Selection of studies.



Source: Own authorship.

Figure 2 presents the results of the risk of bias in the studies using the Funnel Plot (Effect Size - Cohen's Test). The sample size was determined indirectly by the inverse of the standard error. The graph showed symmetric behavior, not suggesting a significant risk of bias in studies with small sample sizes, which are shown at the bottom of the graph.

Figure 2. The symmetric funnel plot does not suggest a risk of bias between the small sample size studies that are shown at the bottom of the graph (N = 25 studies).



Source: Own authorship.

Highlight Findings

The surface types of osseointegrated implants and their macro and microscopic characteristics are of paramount importance for the success of clinical treatment [1-4]. The mechanisms of adhesion and production of calcifiable organic matrix by osteoblasts on the surface of implants are directly influenced both by microscopic conditions inherent to the biomaterial, such as surface tension, surface texture, and chemical composition, as well as macroscopic conditions, such as implant morphology [10].

Microscopic characteristics of biomaterials such as surface tension and chemical composition will not be addressed in this chapter, as they are practically defined and described in detail in various materials engineering publications. However, some innovations in the aspects of implant surfaces introduced in recent years deserve some consideration [11,12]. The vast majority of osseointegrated implant systems commercially available consist of a metal base with or without a special surface treatment [13-16]. The chemical stability, composition, and thickness of this layer are of fundamental importance during the achievement and maintenance of osseointegration [17].

Still, the surfaces of metallic osseointegrated implants are more commonly presented in four types: smooth, previously described in the machining process; sandblasted, with an abrasive powder or through the TPS process (Titanium Plasma Spray); acid etched; and, finally, covered with some ceramic material. The basic objective of any process is to seek a greater surface contact area between the bone base and the implant, in addition to providing a better bed for the osteoblastic cell to adhere to the biomaterial and consequent production of a collagen matrix. In this particular aspect of adhesion, it is known that the osteoblastic phenotype cell adheres more easily and produces its specific protein when in contact with a rough surface compared to a smooth surface [17].

In the process known as TPS, small particles of titanium are heated to high temperatures and blasted onto the surface of an implant that has already been prepared. The impact of these heated particles against the surface of the implant causes its deformation and consequent fusion to the surface metal, forming a shell or blasted layer around the implant [18]. The surface acid etching method has lately been used on a larger scale by manufacturers of implant systems. In this method, chemical compounds with different concentrations are used in the acid etching of the metallic surface of the implant. This acid conditioning forms superficial micro-depressions, increasing the total surface area and characterizing the receptor bed of osteoblastic cells [19].

In this sense, it is clear that there is still no consensus in the dental literature regarding the ideal concentration and time for acid application on the implant surface. It is known, however, that the size of these micro-depressions produced decisively affects the adhesion mechanisms and protein production of these osteoblastic cells. Finally, we have the method of ceramic covering of metallic implants. This coverage is carried out in different ways following the technique adopted by each manufacturer. Generally, for synthetic hydroxyapatite coatings, the plasma spray process is used, where particles of ceramic material are heated at high temperatures and blasted onto the surface of a metallic implant. Several other techniques for applying ceramic coatings have been described, such as radiofrequency blasting, but with similar characteristics in terms of surface produced [18,19].

The new trends of manufacturers of dental implant systems regarding surface treatment and implant design are quite diverse. Some implant systems use both machining and acid etching techniques, combining blasting with abrasive oxide, creating a set of superficial macro and micro retentions. This set is said to be more conducive to osseointegration by the manufacturers that use it, although researchers may differ on definitive answers about the best surface for use in Implantology [1,2,20].

Also, a new method of surface texturing for dental implants was introduced commercially, consisting of electrochemical etching. Allowing control of the thickness of the oxide layer formed, this process is characterized by the manufacturer as applicable to dental implants due to the excellent cellular response found in preliminary studies in animals. The generated surface has a characteristic appearance, similar to a marine coral. However, it should be noted that any modifications to the characteristics of the implant, even if minor, will certainly have a positive or negative influence on the osseointegration process and, consequently, on its clinical success. The evaluation of the performance of these modifications in vitro and in vivo research is of paramount importance before a commercial launch, a procedure that is often abandoned by some manufacturers [20].

The biology of bone repair, which presents the basic conditions that will provide osseointegration or functional ankylosis around implants, has been described in the dental literature. This bone healing is conditioned to the local cellular condition, vascular condition, and nature of the stimulus in the region [21]. The cellular response of interest in osseointegration takes place through 3 specific cells, the osteoblast, the osteocyte, and the osteoclast, the first two with the role of producing and maintaining the bone matrix and the last with the function of bone reabsorption/remodeling.

Also important are the undifferentiated mesenchymal cells, which can differentiate into osteoblastic phenotype cells and ensure the production of calcifiable collagen matrix (type I or II) on the surface of the implant [22]. The vascular condition at the operated site will provide the necessary nutrition for these cells to carry out their specific functions. Also, by releasing specific proteins (growth factors) during the healing process, one can observe the renewal of blood supply in the operated region through vascular neoformation or angiogenesis [22].

As for the stimulus in the operated region, it is known that the bone undergoing post-trauma repair cannot be loaded beyond a physiological threshold of tolerance, under penalty of inducing a cicatricial fibrosis process. Therefore, there is a need to preserve this bone-implant interface from excessive loads in the initial periods of healing, especially in moments involving cell differentiation. The question of what would be the tolerable threshold of load applied to the implant without inducing the formation of fibrosis and what is the ideal time to start applying this load remains under investigation. There is certainly no absolute answer for all cases, as this functional load received by the bone-implant interface will depend on factors such as the total area of the interface, the quality of the bone in question, the size of the implant used and the amount of load distributed to each implant of the restoration [23].

It is of fundamental importance for the successful application of immediate load to implant-supported prostheses [24]. Bone quality and quantity Two anatomical aspects of the bone region to be operated on are of fundamental importance for the prognosis of implants and, consequently, of the implant-supported prosthesis: the amount of available bone and the quality of this bone at the implantation site. The amount of bone in a given region of the maxillary arches determines the length and diameter of the implants to be used. It is directly related to aspects such as the area of the alveolar ridge to be operated on and the presence of anatomical structures in the region [25]. As for the degree of resorption, the amount of bone is directly influenced by the total period of edentulism, factors intrinsic to the patient, and prolonged use of mucous-supported prostheses.

These factors, often combined, act by directly influencing the degree of bone resorption in the implantation area. Results from several published works point to a higher success rate for implants with a larger contact area with the bone base, a direct consequence of the diameter and length of the implants used [25]. Bone quality can be determined by clinical assessment of cortical bone thickness and bone trabecular density in the area receiving implants. The presence of a ridge with purely cortical bone is classified as type I; type II has a rim with thick cortical bone and dense trabeculation; type III presents thin cortical bone with dense trabecular bone and, finally, type IV with thin cortical bone and rarefied trabecular bone. The presence of a type IV bone, with thin cortical bone and rarefied bone trabeculae, a condition usually found in posterior areas of the maxilla, imposes a difficult situation to obtain the primary stability of the post-surgical insertion implant. Consequently, an unfavorable condition is established regarding the prognosis of the implant. A condition of thick cortical and dense bone trabeculae, usually found in the anterior zone of the mandible, allows greater stability for the implant [1,2].

Still, the radiographic resources added to the local observation in the transoperative period are applied in the determination of the amount of bone in the operated area [4]. However, the determination of bone quality is still subjective, since it relies on the surgeon's tactile sensitivity during the first moments of bone base drilling. Attempts to correlate bone density values obtained with computed tomography and bone quality have been described in the literature, but still with little clinical applicability [11].

Thus, regarding the aesthetic positioning of the implant, there are many fundamental factors for the good aesthetic performance of an implant-supported prosthesis. The main conditions of the soft tissues, the amount of bone, and the location and inclination of the placed implant can be cited as the main ones. The correct positioning of the implant is linked to the location and axial inclination of the implant, aiming to favor the emergence profile and aesthetic contours of the prosthesis [13].

For the correct placement of the implant in the edentulous ridge, the surgeon must visualize the threedimensional position of the implant during the surgery and its future relationship with the prosthesis that will be made [12-14]. It is important to use a surgical guide that faithfully represents the final position of the dental crown to be fabricated. Both the inclination in a buccolingual and mesiodistal direction of the implant will influence the contours of the future prosthesis as well as the aesthetics of the soft tissues, mainly in the region of the interdental papillae [15].

In this sense, the ideal location of the implant would be the one assumed by the lost tooth root. Also, the location of the height of the cervical portion of this implant concerning the adjacent teeth is important for determining the prosthetic space available for making the restoration, as well as its emergence profile and the biological space of the surrounding soft tissues [7,8]. Each implant system, as they have different characteristics of the connection between components and cervical design, presents values of ideal distances for the creation of a correct profile of the prosthetic restoration [9].

In this context, for two-stage implants, it is recommended that the level of the cervical surface of the implant be located between 2.0 and 3.0 mm apical to the cementoenamel limit of neighboring teeth [10]. Distances between implants should, on average, present a minimum of 3 mm of available space for the development and adequate nutrition of the gingival papilla, as well as adequate bone quantity. As for the distances between the tooth and the implant, due to the presence of cortical bone surrounding the alveolus and bone crest to support the periodontal soft tissues, a space of 1.5 mm seems to meet the aesthetic and functional needs [11].

In addition, the single implant should ideally follow the location and angulation of the root of the missing tooth [14]. An option to enable a better distribution of loads to the bone adjacent to the implant, in posterior areas, would be the option for two implants to replace a molar or the use of large diameter implants (5.0 mm or 6.0 mm) when the bone condition allows, increasing the bone-implant contact surface and favoring the distribution of loads to the adjacent bone [15].

In an implant-supported fixed partial denture, there is a direct effect of the positioning and angulation of the implants in the distribution of masticatory loads to the bone base [15]. There are descriptions in the dental literature where the reduction of forces transferred to the bone adjacent to the implant can be doubled in the case of a threeelement partial denture with two implants with an anterior cantilever extension, and this same force can be reduced to one third if you eliminate The cantilever was created by adding an implant in the place, positioning the implants in a tripoidal way (not aligned) [16].

Conclusion

It was concluded that the optimized aesthetic positioning of the implant presents numerous factors for the good aesthetic performance of an implant-supported prosthesis. The main conditions of the soft tissues, the amount of bone, and the location and inclination of the placed implant can be cited as the main ones. The correct positioning of the implant is linked to the location and axial inclination of the implant, aiming to favor the emergence profile and aesthetic contours of the prosthesis. The ideal location for the implant would be the one assumed by the lost tooth root. Also, the location of the height of the cervical portion of this implant concerning the adjacent teeth is important for determining the prosthetic space available for making the restoration, as well as its emergence profile and the biological space of the surrounding soft tissues.

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Conflict of interest
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