Review Article

Osseointegration of Dental Implants in Patients with Congenital and Degenerative Bone Disorders: A Literature Review

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ABSTRACT

Aims and Objectives: The aim of this study was to describe the mechanism of dental implants osseointegration in patients with congenital and degenerative genetic bone disorders. **Materials and Methods:** A PubMed and Scopus documents search was carried out between November 2021 in the, using words such as "osseointegration," "degenerative disease," "congenital disease," and "dental implants." **Results:** The thirteen articles selected dealt with dental implants osseointegration in patients with congenital and degenerative bone disorders. The influence and repercussion of these diseases on the bone system, as well as the osseointegration process were described from healing to bone remodeling. In addition, certain articles described some considerations to improve the osseointegration process in patients suffering from these types of conditions. **Conclusions:** Within the limitations of this literature review we can conclude that osseointegration in patients with ectodermal dysplasia and osteoporosis could be achieved. However, the planning process for dental implant placement in these patients should be more meticulous and individualized considering the degree of tissue involvement as well as the patient's age and skeletal development compared to systemically healthy patients.

Keywords: *Congenital disease, degenerative disease, dental implants, osseointegration*

Introduction

Dental loss is one of the factors that will cause negative effects on people at the esthetic, functional and social levels, causing changes in the lifestyle and quality of life of individuals.[1] The methods for managing tooth loss have evolved over time. Currently, dental implants are an alternative treatment to replace missing teeth in the mouth.[2,3] Dental implants procedures are closely related to the term osseointegration which was introduced by Per-Invar Branemark who described through histological studies the fixation of a biomaterial to the bone tissue, where it was observed that the inflammatory and bone cells reacted immediately with each other, leading to the process of bone regeneration regulated by biological factors.[4] This biological tissue response to a biomaterial is given by the osteocytes that oversee continuously maintaining the osseointegration of dental implants, since through their canaliculi they will adhere to the biomaterial.[5] This whole process would be compromised if the bone structure is unstable and there is a certain degree of failure during the osseointegration process of a dental implant. Therefore, it is important to mention that people who present bone genetic alterations that do not allow dental structures correct development. Hence, certain conditions such as cortical and trabecular bone architecture may influence bone quality and strength supporting forces.[6]

Genetic disorders that compromise the skeletal system will comprise a group of conditions that will differ in

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their clinical and genetic characteristics. With respect to clinical features, these can range from neonatal mortality to mild growth retardation. These skeletal disorders are divided into dysostosis, which refers to individual bone's malformations, and osteochondrodysplasia, related to developmental disorders of the chondro-osseous tissue.[7]

Congenital diseases can be genetically determined, idiopathically induced or caused by lesions during development.[8] Among these diseases we find ectodermal dysplasia, which is characterized by anodontia, hypodontia and conical teeth manifestations which are associated with decreased growth or underdevelopment of the alveolar bone.[6] This congenital absence of teeth includes abnormal tooth eruption patterns, widely spaced teeth with reduced width and salivary hypofunction.[9] For example, osteoporosis has been studied because it is considered a degenerative disease and it has been found that the imbalance in bone remodeling causes a continuous decrease on bone quantity for adequate dental implant placement.[10] Both the quality and quantity of alveolar bone are important for the successful permanence of dental implant placement.[11] Therefore, the absence of alveolar bone formation will lead to diagnostic and treatment challenges.[9]

The purpose of this literature review was to describe the mechanism of osseointegration of dental implants in patients with congenital and degenerative genetic bone disorders to determine implant treatment success or failure rates under these conditions.

Materials and Methods

Search strategy

A bibliographic search was performed in the month of November 2021 in the Pubmed and Scopus databases, using words such as "osseointegration," "degenerative disease," "congenital disease," "dental implants." The records obtained were a total of 25 articles after combining different key terms. The following formula was used and adapted for each base: "osseointegrate"[All Fields] OR "osseointegrated"[All Fields] OR "osseointegrates"[All Fields] OR "osseointegrating"[All Fields] OR "osseointegration"[MeSH Terms] OR "osseointegration"[All Fields] OR "osseointegrative"[All Fields] OR "degenerative disease"[All Fields] OR "congenital disease"[All Fields] OR "dental implants"[All Fields]

Inclusion criteria

Descriptive correlational and retrospective studies; case series, analytical cross-sectional case-control studies, and longitudinal cohort studies.

Exclusion criteria

Conference abstracts and editorials, letter to the editor, book reviews and empirical reports.

Results

Of the 26 articles used for the preparation of this literature review, 11 were used for the introduction, and of these, 2 were included in the results. Thirteen articles were selected, of which 2 were descriptive (one correlational and one retrospective); 2 articles were analytical case-control; 1 longitudinal cohort study; 1 case series; 1 pre-clinical study (animals); and 1 was a case report.

Eight studies were selected for discussion. Three of them focused on ectodermal dysplasia and five on osteoporosis. The main characteristics of the different articles used for this review are detailed in [Table 1].

Osseointegration

Osseointegration is a term introduced by Branemark in 1977 referring to the connection given between the bone-implant contact to prevent movements.[12] The osseointegration process originates from bone tissue healing starting with cellular hemostasis and through the accumulation of fibrin on the blood clot.[13,14] Bone regeneration can occur in two ways such as contact osteogenesis where forming cells (osteoblasts) are positioned on the implant surface and distance osteogenesis where these osteoblasts migrate towards the cavity where the implant has been positioned.[13] Dental implants bone healing begins with intramembranous osteogenesis for bone-tissue formation and continues with the development of lamellar bone and parallel fibers. Implant surface bone apposition follows the pattern in trabecular bone first followed by apposition on the cortical bone. Although the first new bone formation can appear approximately one week after dental implant installation, bone remodeling occurs between the sixth and twelfth week and continues with the times.[15]

Congenital bone alterations

Congenital bone alterations include a series of malformations due to genetic or idiopathic origin, or may occur during embryonic development through medication, exposure to radiation, hormonal imbalance, or trauma. One of the processes that crucially influence bone augmentation is hematopoiesis, unbalancing osteogenesis and at the same time osteoclasts are also important during blood–bone interaction, providing an optimal environment for hematopoiesis through bone resorption leaving space for bone marrow accommodation.[8]

Table 1: Description of the main characteristics of the selected studies

Author	Diseño de estudio	Sample size	Disease	Main findings
Silthampitag *et al.*[6]	Descriptive correlational study	9	Ectodermal dysplasia	Female ED bone is more compact and more trabecularly connected than male bone, which may influence the results of implant treatment.
Zou *et al.*[17]	Retrospective descriptive study	25	Ectodermal dysplasia	Hypohidrotic ectodermal dysplasia patients bone volume can be augmented using different biomaterials. Patients with ectodermal dysplasia can be effectively reconstructed with implant-supported prostheses and bone augmentation.
Machado *et al.*[9]	Case series	6	Ectodermal dysplasia	Dental implants rehabilitation achieved encouraging results, with consistent benefits after prosthesis placement follow-up from 1.5 to 6.6 years.
Wagner *et al.*[25]	Case-control study	244	Osteoporosis	No contraindications were reported in osteoporotic patients.
Merheb *et al.*[11]	Case-control study	73	Osteoporosis	Implant stability was influenced by both local and skeletal bone densities. Lower stability scores were reported in patients with skeletal osteoporosis.
Friberg *et al.*[23]	Cohort study	16	Osteoporosis	The best implant stability was achieved by adapting the preparation technique and extending the healing period. Dental implants performed similarly to those placed in denser bone textures, showing that success over a period of many years is possible in these cases.
Siqueira *et al.*[24]	Animal research	50	Osteoporosis	A hydrophilic implant surface improved osseointegration in the presence of osteoporosis. In addition, the amount of calcium and phosphorus content increased.
Marchand *et al.*[26]	Case Report	10	Osteoporosis	Maxillary sinus elevation showed a correlation with microarchitectural bone changes and could be a useful approach for osseointegrated grafts in osteoporotic patients.

Metabolic bone disease

It encompasses a series of systemic diseases which present complex manifestations and cause a generalized alteration of metabolism, which affects the bone system to certain degrees. In this group of diseases there are alterations in bone modeling that are present from the first years of life and there are also alterations in bone remodeling that occur in adult diseases.

Bone remodeling can be altered when there is bone formation and bone resorption imbalance, which can occur in the following way: 1. If the balance is negative, it means that there is a bone mass reduction which can result in osteoporosis. 2. When the primary bone does not present good mineralization, this will impair remodeling, causing the appearance of osteomalacia. 3. It is probable that bone resorption in certain areas does not support the creation of new bone, contributing to the appearance of lytic areas which are made up of fibrous tissue (cystic fibrous osteitis, a classic bone lesion of hyperparathyroidism). Furthermore, when remodeling occurs in a rapid and disordered manner, it produces a bone with abnormal trabecular architecture, the same occurs in Paget's disease.[16]

Ectodermal dysplasia

Ectodermal dysplasia is a congenital genetic disease characterized by causing certain abnormalities in teeth, bone, skin, hair, salivary, and sebaceous glands. It is classified into hypohidrotic and anhidrotic ectodermal dysplasia, being considered the most common, the X-linked hypohidrotic, which affects only in some respects to women and men inheriting the entire genetic pattern. In the field of the stomatognathic system, this hereditary disease affects the shape, size and number of teeth as it has been shown that they present peg-shaped teeth or also hypodontia or anodontia which may also be due to the affection of the salivary glands causing xerostomia, among other conditions. For this reason, in cases of anodontia, the way to perform a bone augmentation by different means or surgical interventions for implant treatments has been studied to return both basic and esthetic functions.[17-19]

Three studies evaluated the relationship between ectodermal dysplasia and bone conditions where dental implants were placed. Silthampitag *et al.* analyzed the microarchitecture of bone in relation with implant placement in young ectodermal dysplasia patients. Bone samples were collected from different anatomical sites,

Table 2: Comparative table between diseases

Characteristics	Ectodermal dysplasia	Osteoporosis
Type of disease	Congenital.[18]	Bone metabolic[16]
Prevalence sex	Men and women.[18]	Women[16]
Etiology	Mutations in genes of the ectodysplasin/NF-κB pathway (EDA1, EDAR, EDARAAD, AND WNT10A).[18]	It appears more frequently with bone reduction over the years. In women, ovarian function diminishes at menopause accelerating bone loss.[16]
Starting age	From birth.[19]	From menopause onwards, generally 60 years of age approx.[16]
Signs and symptoms	Hypohidrosis, anodontia, hypodontia, hypotrichosis, problems with thermoregulation, dystrophic nails and palmoplantar keratoderma.[19]	Asymptomatic until the onset of complications, indicators such as osteoporotic fractures are usually used to approximate the prevalence of osteoporosis.[16]
Affection to the bone structure	Diminished alveolar ridges, thin enamel layer and in some cases hypoplasia.[19]	Decrease in bone mass and deterioration of tissue microarchitecture. Imbalance between the bone resorption and remodeling process in which resorption exceeds formation.[16]
Diagnostic test	Clinical, genetic testing, skin biopsy.[19]	Bone densitometry, quantitative computerized tomography

one from the implant site and another in the adjacent area where the extraction was performed, where it was observed that the mandibular bone samples of women had as characteristic a denser compact bone, and a greater bone volume in comparison with that of men. This may evidence that the female bone sample had a better trabecular connection.[6]

In another study where an increase in bone volume was performed by means of autosomal grafts, artificial bone and osteogenesis by vertical distraction, a higher dental implants success was evidenced, with few cases of failure due to peri-implantitis and bone loss.[1] In the research of Machado *et al.*, dental implant placement was performed with dental extractions and bone grafts with a follow-up of 1 to 6 years, which showed encouraging results and great satisfaction in patients with ectodermal dysplasia.[9]

Osteoporosis

According to the World Health Organization, it is considered a systemic disease characterized by the deterioration of bone density, which leads to fragile bones and, consequently, to a greater probability of suffering fractures, where women are the most predisposed to suffer this type of condition. This disease occurs when there is bone formation (osteoblastic activity) - bone resorption (osteoclastic activity) imbalance.[11]

Bone remodeling is necessary as a calcium reservoir to meet the needs of plasma calcium homeostasis. There are two remodeling categories: a. Microdamage repair and bone tissue mechanical integrity preservation, and b. Bone remodeling which supports plasma calcium homeostasis. If the remodeling is excessive, bone strength could be affected. This can be weakened through bone mass loss due to trabecular penetration. In addition, an excessive activation of the resorption and reversal phases, may cause excessive weaken of bone trabeculae. Also, the excessive activation of resorption may cause an excess of weakened loci in trabeculae which exceeds the repair capacity.[20]

A comparative table of the main characteristics of the diseases studied, ectodermal dysplasia and osteoporosis, located in [Table 2], was elaborated.

Treatment planning for patients with bone disorders

The planning of implant placement, bone grafting and healing time will depend on whether the patient has a medically controlled systematic bone disease. Patients with these bone disorders should be considered to have a risk factor that may alter all bone repair processes. For this reason, it is recommended that a thorough diagnosis and treatment plan aligned to the systematic conditions of the patient with bone disorders be carried out before intervening on the patient.[9,10]

Discussion

A series of studies support the fact of being able to restore the basic functions of the stomatognathic system in patients with ectodermal dysplasia based on good planning. Therefore, it is very important to evaluate the conditions of the patient and the necessity to involve multiple specialties, including implantology, using alternative methods such as bone augmentation by bone grafts to perform the treatment with dental implants with a high success rate. Besides this can increase the quality of life of the patients, in order to feel satisfied with the pathology results.

It is a great challenge to treat this type of disease since certain tissues derived from the ectoderm are compromised, affecting in this case the teeth, characterized by the partial or total teeth absence, conditioning the alveolar bone quality.[9] Therefore,

the clinician should meticulously evaluate the factors that may influence the treatment, such as skeletal development, the degree of tissue involvement, as well as the patient's age,[21] considering that in people without any type of disease affecting bone quality, osseointegration is carried out successfully.[22] It should also be considered that different methods are applied for bone augmentation as in the study of Zou *et al.* where autografts, Bio-Oss as artificial bone and the surgical technique of vertical osteogenic distraction were used, having optimal results, with a high percentage of success of the treatment during a follow-up of 3 to 5 years, with few cases of peri-implantitis.[17]

Another important aspect is to consider the implant surface, since this will influence the speed of healing, leading to the possibility of coupling in a bone environment with certain disadvantages, as in the case of patients with ectodermal dysplasia, favoring osseointegration.[23] In the study of Siquiera *et al.* where titanium implants of hydrophilic and hydrophobic surface were used, it was evidenced that the implants that favored osteogenesis in both healthy and compromised conditions were those of hydrophilic surface.[24]

On the other hand, medical compromised patients with osteoporosis presented a decrease in bone density and a defect in the microarchitecture, which can lead to an increased possibility of bone fracture. Many studies reported that dental implants placement is not contraindicated in people who suffer from osteoporosis, as in the study of Wagner *et al.* where the effect of osteoporosis on the peri-implant surface in postmenopausal women was evaluated, showing favorable results with an influence of this disease on bone remodeling, indicating that the level of the alveolar bone should be respected at the time of implant placement in order to avoid future complications.[25] Also, the study of Merheb *et al.* assessed both local and skeletal bone densities and divided the recruited patients into three groups: with osteoporosis, with osteopenia and the third was a control group with healthy women. They found a moderate relationship between skeletal bone density and implant stability achieving the survival of all the implants placed. It also was recommended to follow safe protocols and longer healing times when placing dental implants.[11] Friberg *et al.* performed a retrospective study in with osteoporotic patients being subjected to dental implant treatment. Implant placement in these patients succeeded over a period of many years.[23,26]

The limitation of this study was the sparse literature of original articles with the information needed to conduct research on osseointegration of dental implants in patients with ectodermal dysplasia and osteoporosis. Another limitation was the restricted accessibility to various journals containing articles on the relationship between congenital and degenerative diseases affecting osseointegration. However, we tried to collect as much information as possible to achieve the objective of this review article and to be considered as a source of consultation.

Conclusion

Within the limitations of this literature review we can conclude that osseointegration in patients with ectodermal dysplasia and osteoporosis could be performed, but the planning process for dental implant placement in these patients should be much more meticulous and individualized considering the degree of tissue involvement as well as the patient's age and skeletal development compared to systemically healthy patients.

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Conflicts of interest

None to declare.

Authors' contributions

EP, LS, FMT: concept and design of study, drafting, and revision. FMT, RM, and MEG: acquisition of data, analysis, and interpretation. JO, RM, MEG, FMT, EP, LS: acquisition of data, interpretation, and drafting. Finally, all authors had given approval of the version of the article to be published.

Ethical policy and institutional review board statement

Not applicable.

Patient declaration of consent

Not applicable.

Data availability statement

The data that support the study results are available from the author Dr. Frank Mayta-Tovalino, e-mail: fmaytat@unmsm.edu.pe, on request.

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