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Tribocorrosion-titanium dental implant allergy- do we really know what we know -An overview

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Abstract

The purpose of this review article was to describe the current state of knowledge and understanding of the allergies to titanium dental implants. Titanium is used for making implants to replace the teeth and associated structures and is now common in dental practice. But there are relevant papers where it is shows titanium particles can be released from the surface of dental implant in a process called "Tribocorrosion". Allergies to titanium are uncommon but represent a real possibility that should not be overlooked in patients requiring prosthodontic rehabilitation with dental implants.

Keywords: Tribocorrosion, Titanium Implants, Corrosion, Hypersensitivity, Allergic Reactions.

Introduction

Titanium (Ti) is a transition metal known for its high resistance to flexion and corrosion. It has been used in many different fields; for military and in aerospace, for sports equipment, jewelry etc. [1-3]. From the earliest days of implant dentistry, titanium has been considered the gold standard material for fabricating dental implants due to its excellent biocompatibility, strength and osseointegration capacity [4]. Most researchers agree that titanium is the least allergic metal among the material of choice for biological purposes [10-11].

The first case involving dental implants was reported in 2008.

Mechanisms that trigger allergies to titanium

Titanium and its alloys show the highest resistance to corrosion of all metals. Commercially, pure titanium forms a passive oxide surface film when exposed to an aqueous medium or air, which creates high immunity to corrosion by acids, chlorides and wet environment, the degree of ion elution being very small. This makes commercially pure titanium and its alloys virtually free of corrosion [7]. However, any break in the oxide layer can produce corrosion and affect biocompatibility [8].

Titanium has an innate resistance in aqueous chloride containing environments. When titanium is in a passive condition due to the thin oxidation of titanium surfaces,

corrosion rates are less than 0.02 mm/year [9] and well below the maximum corrosion rate commonly accepted for biomaterial design and application [10].

It has been suggested that any mechanical disruption during insertion or damage to the abutment connection or the extraction of defective implants may cause particle release from the metallic structure. Suarez-Lopez del Amo et al. [11] mentioned the higher prevalence of titanium particles of various sizes in peri-implant disease compared to healthy implants; in turn, the most common reasons for their release into the peri-implant medium being corrosion, implant insertion, implant-abutment friction. Concentration of between 100 and 300 ppm have been reported in peri-implant tissues, often accompanied by discoloration [12].

Moinbelli et al. [23] they considered that there is some biological possibility for link between corrosion, presence of titanium particles and biological complications. Mechanical wear and corrosion, together with environmental factors, contact to chemical agents, and interaction with substances produced by adherent biofilm and inflammatory cells will lead in some cases to material degradation in a process called Tribocorrosion.

The European Association for Osseointegration (EAO) consensus conference 2018 published a final statement [13], which includes an extensive discussion of the effect of titanium particles and biocorrosion on implant complications and subsequent survival rates. According to the statement, a number of in vitro studies have reported that the acidity of the oral environment caused by bacterial biofilm and/or inflammatory process can provoke titanium particles release in a process known as “Biocorrosion”. The resulting titanium debris upset the balance between bone formation and resorption in two ways: - through direct osteoclast and osteoblast activation and through the stimulation of inflammatory cytokines secretion from macrophages and lymphocytes.

The elements in titanium alloys can be classified as stabilized in the alpha phase, the beta phase, or both. Increasing the alpha phase boosts stability at high temperatures, while increasing the beta phase increase resistance to ambient temperature and the durability of medical titanium. Titanium alloys (consisting mainly of titanium, aluminum and vanadium: (TiAl6V4) are the most widely used option for dental implants in comparison with pure titanium (TiO2) due to their high strength. It should be noted that even pure titanium has impurities that can trigger allergic reactions.

Aluminum in implant alloys acts as an alpha phase stabilizer and reduces the weight of the alloy. Vanadium is a stabilizer of the beta phase and reduces possibility of corrosion. More recently vanadium free alloys have been developed. (Ti-6Al-7Nb and Ti-5Al-3Mo-4Zr) that exhibit equal good mechanical properties [1, 3, 25].

Clinical characteristics of hypersensitivity to titanium

The orofacial region is associated with type I, III and IV allergic reactions. Type I is considered an immediate allergic reaction to external allergens with local and systemic anaphylaxis. In type III reaction, a large quantity of circulatory antibodies is observed, produced between 2 and 8 hours after implant placement [1]. Type IV is considered the most frequently occurring allergy to metal, characterized by the local presence of abundant macrophages and T-lymphocytes and the absence of B lymphocytes. Type IV or delayed type, develops after repeated contact between an allergen and the skin or the mucosa, it occurs during the first 24-72 hours. Although the symptoms may appear at any time up to 14 days after surgery. Immune sensitivity may manifest at some distance from the implant and may even demonstrate a

systemic reaction that remain unnoticed or may be incorrectly interpreted. [1, 14, 15]

Clinical manifestations of hypersensitivity to titanium.

Localization	Symptoms
Local Manifestations	Hives, edema, eczema, reddening, and itching of the skin or mucosa, erythema, contact dermatosis, atopic eczema, bullous eruptions, proliferative hyperplasia tissue/edematous tissue/non-keratinized tissue, peripheral giant cell pyogenic granuloma
Manifestations at a distance from the implant place	Hives, disseminated facial eczema, edema, reddening, and itching of the skin or mucosa, atopic dermatitis
Systemic Reactions	Pain, necrosis, weakening of orthopedic implants, disturbed fracture healing, nervous disorders, chronic fatigue syndrome, neurological problems, depression, multiple chemical sensitivity

Test for identifying metal allergies

Various diagnostic tests are available to assess allergies to metals in general and titanium in particular. In epicutaneous patch testing, substance located on the back or forearm is evaluated over 3-7 days period [10, 16]. The epicutaneous patch test is one of the most common and important tests for metal allergy.

Patch test reactions are interpreted by using criteria similar to International Contact Dermatitis Research Group (ICDRG) criteria. [17]

However, because of skin qualities of sealing and protection against direct contact, the test is not very sensitive and may give a false positive or negative and only detects some 75% of type IV metal allergies [18]. Lack of standardization may limit the use of patch test. Nevertheless, it is the most widely used test despite the fact that it is not completely accepted to be the most effective. [2, 19-21]

In the cutaneous injection test (in-vivo), the allergen is injected intradermally in the forearm. Red papules and vesicles are considered to show a positive result. This test is only recommended for type I allergies and not for oral allergies. The lymphocyte transformation test (LTT) is applied in-vitro for mucosa sensitizing allergens. Both local and systemic effects can be analyzed with this test. The MELISA test (Memory Lymphocyte immune-Stimulation Assay) is test modification the LTT test.

Titanium Allergy Management

The scientific literature includes very few indications or instructions for management of patients undergoing a process of hypersensitivity to a titanium dental implant. As already mentioned this is because dental professionals consider that titanium is one of the most bio compatible metals for implantation in the body; they do not believe that allergic reaction will appear or that they have sufficient clinical relevance to warrant and established and made available.

Discussion

The scientific literature repeatedly insists on the success of titanium implants. Nevertheless, the so called Tribocorrosion process release titanium ions into the surrounding tissues, which can trigger a cascade of reactions, localized or at distance or even systemic reaction (1, 22, 18, 23, 24, 20). Various test for allergy to titanium is described in the literature, the patch test being the most frequently used (2, 19-21).

This review represents the current, relevant knowledge about allergies to titanium dental implant and their management. The scientific literature on this topic is very less, which highlight the need to establish a protocol. For those patients who are sensitized to titanium before and after the placement of dental implants and in patients with a history of metal allergies (25,26). When the dental implants are placed in the jaws, and then patient prove allergic to titanium. Decision on ratio of risk/benefit to patient must be considered. If patient show no clinical improvement, remove all the titanium implants and zirconia dioxide implants (ZrO2) or yttria stablized zirconia offer a promising alternative as no case zirconia oxide has been reported (27-29).

Conclusion

Within the limitation of this review, it may be concluded that allergies to titanium are uncommon, although they do present a real possibility that should not be overlooked. When it comes to treating patients requiring prosthodontic rehabilitation with dental implants. Literature points to lack of standardization in research into titanium allergy. Further studies are needed with adequate protocol, sample size and follow- up, which would obtain clear and more reliable results.

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