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International Journal of Current Research
Vol. 7, Issue, 04, pp.15172-15175, April, 2015

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

REVIEW ARTICLE

NON INFECTIOUS FAILURE OF DENTAL IMPLANTS: A CLINICAL VIEW

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ARTICLE INFO

Article History:
Received 30th January, 2015
Received in revised form
09th February, 2015
Accepted 23rd March, 2015
Published online 30th April, 2015

Key words:
Implant,
Corrosion,
Failure.

ABSTRACT

Strong and healthy teeth forms the basis for beautiful and attractive smile and can be a reason for overall growth and good health of an individual. Missing teeth can cause drifting of existing teeth into the edentulous space that leads to the collapse of the bite, resulting in serious health complications including TMJ disorders, sleep disorders and muscle disorders. Over the years, dentists have evaluated many functional, comfortable, and affordable ways to replace the missing teeth. There are many options to replace the missing teeth, either with a removable partial denture, fixed partial denture and complete denture prosthesis. Recently, the dental implants the most resilient, metallic materials have been introduced that are more aesthetically pleasing and comfortable. Dentists must be implicated with the biological reactivity of the materials they use, as these materials can be allergic and toxic. The responses can be immediate or delayed. A wide variety of symptoms can occur including, chronic inflammation, cancerous conditions, and neurologic disorders, leading to generalized illness.

INTRODUCTION

From past four decades, implants have acquired the greatest importance in all the fields of dentistry and medicine. Of these, dental implants are routinely exposed to high mechanical, cyclic and occlusal loads such as friction, detritions, and wear out together with multiaxial fatigue. Sustaining these loads is one of the most important tasks of these implants which are complicated by the need to survive in bodies' electrolyte environment such as blood, saliva, proteins, enzymes, acids and salts that are very corrosive in nature. Even though titanium and its alloys is one of the most corrosion resistant metals that forms a very stable oxide layer in physiological and biologic environment with exceptional biocompatibility as compared to other metallic implant materials, the reactions on the surface of titanium do occur. Such as, adsorption of proteins, ion exchange or enzymatic reaction, all these reactions do not harm the properties of titanium implants that determine the stability of the implants within the bone, by consequently mechanical activation of the surface oxide layer that plays an important role in successful osseointegration of dental implants. Biocompatibility is most important property of all the materials used in dentistry, hence materials used in dentistry should be tested and evaluated carefully as it is always an most important concern in the dentist's goal of restoring the missing teeth, to maintain the optimum health and function of an individual. Biocompatibility is the term refers to how a material reacts and interacts with the human body and how those interactions determine the clinical success of these restorative materials. Hence these materials are available in improved forms through the years; still, no material is available that can duplicate the physical and chemical properties of human dentition or bone (Daniel *et al.,* 2009).

Dental implants are always considered as better options in replacing and restoring missing tooth/teeth. Implants have more aesthetical and functional advantages compared to other materials used for replacing missing teeth, such as fixed partial denture and removable partial dentures that always require the support from adjacent teeth as abutments that can potentially harm and damage the vitality of the tooth. However, the innovation of newer materials such as dental implants can be used to replace and restore missing teeth, dental implants can support, stabilize and strengthen the adjacent teeth and maintain the bony architecture and also can preserve the vitality of adjacent teeth (Charles, 2001).

The implants are more comfortable and offer good strength, stability, exceptional chewing capacity and are aesthetically more pleasant (Michael Baylin, 2012; Manoj Mittala, 2011). The introduction and evolution of dental implants have served many patients well since many years, the implant that have better success rate of approximately or more then ninety-five percent. After many scientific research works and clinical success rate, the implants can be used as permanent solution material for missing teeth. Titanium material has prevailed as the base material for implants because of their good

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biocompatibility and successful osseointegrating property, this metal is well tolerated biologically (Michael Baylin, 2012; Kenneth, 2003).

The clinical success of titanium implants for dental applications depends on the systemic health and also ability of surrounding bone tissue to osseointegrate with the surface of the implant, and it remains far from ideal in patients with systemic disease. The implants fail in compromised and unhealthy bone due to various systemic, anatomic and physiological factors. The interface between the implant and its peri implant tissues is assessed in situ by means of systematic, clinical and histological research studies. The human dental implant failure is most often caused by mobility, metal fracture (fatigue) or early exposure. It is worth noting that the interface of implants that have failed due to metal fatigue are found to have good osseointegration with surrounding bone tissue. The metal particles included in the osseointegrated bone tissue and the bone medulla of implants that failed due to metal fatigue, providing evidence of the corrosion of the metallic structure. Bone cells are more sensitive to the chemical byproducts produced during corrosion phenomenon; the electrical signals associated with corrosion might affect the osseointegration.

The corrosion process may limit the metal's resistance to fatigue, compromising its resistance, which may eventually cause the fracture of the implant. It has been reported that saliva and other electrolytes leaking between the suprastructure made of other metal and the implant made of titanium alloy may trigger a corrosion process (galvanic corrosion) due to differences in electrical potential. The present article describes the cause and types of corrosion associated with dental implants with various manifestations of allergic reactions to implant materials and available diagnostic tests for allergic reactions (Manoj Mittala, 2011; Gittens *et al.,* 2011; Kean-Khoon Chew *et al.,* 2012; ArthroplastySchuh *et al.,* 2008).

DISCUSSION

The oral cavity provides a ideal environment for study of chemical, biological, physiological processes and reactions involving various metallic and non metallic dental materials. The oral cavity has to function in one of the most inhospitable environment in the human body. The dental materials within the oral cavity react and interact continually with salivary fluids and other oral fluids. Due to the acidic nature of oral fluids varies due to the salivary Ph that ranges from 5.2 to 7.8. The teeth, various types of restorations and prosthesis including dental implants are subjected to higher Ph and temperature variations than most of the other parts of the human body. Fluoride content present in oral cavity and the restorations is also known to cause corrosion of implant materials, as fluoride is well known as a specific and effective caries prophylactic agent and its systemic application has been recommended widely from decades. Nevertheless, the content of high fluoride concentrations in oral cavity impair the corrosion resistance of titanium and other metallic materials. Corrosion, the graded degradation of dental materials by electrochemical reaction, is of concern particularly when dental implants are too be placed in the hostile electrolytic environment provided by the human oral cavity (Gittens *et al.,* 2011). Furthermore, the placement of dental implants in the oral cavity may also lead to internal exposure of implants which ultimately leads to titanium ions to concentrate in oral tissues, regional lymph nodes, and pulmonary tissue. Concentrations of about 300 ppm have been discovered in peri-implant tissues, often accompanied by discoloration of peri implant tissue, the presence of titanium and its alloy in the lungs was observed to be equal or more then 2.2–3.8 than normal, and 7.0–9.4 times more in the enlarged lymph nodes (ClinCosmetInvestig, 2013). The metallic nature and properties of the materials used for dental implants and the corrosive environments found in the oral cavity, in combination with the continuous stress and cyclic loads to which these implants are subjected, may cause corrosion due to its corresponding electrochemical byproducts. These electrochemical byproducts produces electrical waves that can convert any kind of metallic implant into an electrode and can create negative impact on the surrounding bone tissue, that can be the reason for rejection or failure of osseointegrated implants (ClinCosmetInvestig, 2013; Gittens *et al.,* 2011; Kenneth, 2003).

Metals possess stable and passive property, where the oxide layer has self-healing property that immediately after being ruptured under stress can heal and also prevent the implant from corrosion, but in conditions like unstable passivity, where the oxide layer once ruptured under stress is incapable of healing and hence the metal is directly exposed to corrosion. Hence such events depend on the reducing and oxidizing potential of the surrounding environment. The passive oxide layer formed on the surface of titanium may be responsible for its good resistance to corrosion. In certain cases the metals get exposed to corrosion that leads to implant failure without causing infection. The most common types of corrosion found in metallic materials used for implant applications are galvanic, fretting, pitting/crevice, intergranular and stress corrosion as well as environmentally induced cracking (Daniel, 2009; Patients.Sicilia, 2008; Ralph *et al.,* 1983).

Galvanic corrosion usually occurs when two dissimilar metals come in direct contact with each other in presence of an electrolytic solution. The difference and variations in between the electrochemical potential of the two dissimilar metals promotes oxidation of the more reactive metal. Galvanic corrosion rarely occurs in dental implant material because the implant is made up single metal component, the insulating nature of the protective passive layer that forms on the surface prevents it from corrosion. Nevertheless, in some individuals the surrounding tissue and fluid contents could serve as a medium for electrical flow between metallic implants and other types of alloys used in dentistry like Amalgams restorations, gold fillings, and orthodontic appliances. Galvanic corrosion could also be the reason or might aggravate the corrosion initiated by fretting and/or pitting corrosion (Kenneth, 2003; Charles, 2001).

Fretting corrosion is caused by the repeated friction or micro-motion of a metal component against another material that causes cracks, mechanical wear and breaks up the passivating layer on the surface of the metallic device. Fretting between dental implants and bone during implantation and due to cyclic loads imparted from chewing has been suggested as a cause of Ti corrosion and metal ion release. Recent studies have shown that fretting and oxide disruption at the surface of load-bearing implants can cause corrosion (Kenneth, ?; Charles, ?). Pitting corrosion forms as a result of the spontaneous breakdown of the passive layer on the metal, the exposed area comes in contact with chloride containing corrosive media of body electrolytic fluids. These pits may nuclease at the site of metallurgic defects, inclusion, scratches on the surface, or some other area. Once the pit is nucleated it does not reform rapidly, these metal ions then precipitate solid corrosion products. Implant failure in the form of loosening without infection, or osteolysis, may result from release of corrosion products in the form of wear debris or electrochemical products generated during corrosion events (Daniel, 2009; Juliana, 2011; Gittens, 2011; ArthroplastySchuh, 2008; William, 2005).

Intergranular Corrosion

Heterogeneous intergranular distribution of carbon was observed in surgical grade metals, resulting in intergranular corrosion due to the formation of chromium carbides. Since then, surgical specifications have demanded lower and lower carbon content. It is only when the carbon content of austentitic stainless steel is below 0.03% are the carbides reproducibly absent, thus greatly reducing the risk of corrosion.

Crevice Corrosion

Crevice corrosion is usually formed by covering or shielding a portion of metal from a corrosive medium, the area between a metal post and prosthetic tooth is one example. The shielded area has a limited access to the surrounding solution which contains corrosive species such as chloride ions. Since the assess is limited, metal ions and hydrogen ions build up with a corresponding lowering of the oxygen concentration. The shielded area becomes the anode and non shielded area becomes the cathode. The chloride ions move into crevice due to charge effects and cause more damage.

Stress corrosion cracking

Dental implants are subjected to continuous stress in the body. Even ductile materials tend to fracture under stress, in less ductile metal tends to form micro cracks, the passive film is ruptured and the metal is exposed to corrosive environment. The small ruptured area becomes anode and rest of the area becomes the cathode that may form corrosion (Kenneth, ?; Ralph, 1983; Charles, 2001). Metal traces originating from dental implants have been found in blood, liver, lungs, and lymph nodes. These metal ions and wear debris may also contribute to aseptic loosening by promoting inflammatory complications that may result in macrophage activation, bone resorption, and, rarely leads to the potential development of neoplasia. Recently, titanium dioxide (TiO_2) was classified as possibly carcinogenic to human beings at the International Agency for Research on Cancer (Juliana, 2011; ClinCosmetInvestig, 2013; Gittens, 2011).

The electrical waves of corrosion byproducts and its effect on the surrounding tissue may be the reason, but such effects implant failure without infection. Corrosion events generate abnormal electrical waves due to electron transfer from ions in the solution to the metallic surface of implants where reactions take place. These abnormal electrical potentials are directly related to the stress and cyclic loads applied onto the implants. In dental and orthopedic applications, cyclic occlusal loads are to be expected from the forces exerted after every bite, the cells and tissues in individuals with implants are exposed to abnormal electrochemical signals for longer duration of time.
As bone cells are more sensitive to electrolytic signals and thus, could be strongly affected by these corrosion currents and byproducts. Moreover, these abnormal electrical waves might provide us with etiological causes of inflammatory complications and eventual aseptic loosening and failure of dental implants (Gittens, 2011; Kenneth, 2003). Following tests can be performed to check various types of allergies (Patch test, Prick test, Lymphocyte transformation test, Memory lymphocyte immune stimulation assay)

Patch tests: After applying different allergens on the back of the patient, the consequences of the allergens are evaluated, in the positive test for an allergen, the area of skin related to the tested allergen will show erythematous reactions, vesicles, and etching. Patch tests are limited in use due to their poor sensitivity, which has been demonstrated for approximately 75% of type IV metal allergies. Lack of standardization for certain metals like titanium may limit the use of a patch test.

Prick test: This test involves intradermal inoculation of the allergen. It is analyzed within 15 to 30 minutes. Red, papular, and/or vesicular reactions of the skin may appear in positive test conditions.

The lymphocyte transformation test is applied by an in vitro method in mucosal sensitizing allergens. The optimized version of LTT is known as Memory Lymphocyte Immuno Stimulation Assay (MELISA). Local and systemic effects of hypersensitivity resulting from allergies can be analyzed by this method (ClinCosmetInvestig, 2013; William, 2005). An allergic evaluation for titanium is indicated in patients who gave a past medical history of allergic to metal ions. In hostile circumstances of oral cavity, lower pH phenomenon in a peri-implant region an inflammation to implant undergoing heavy mechanical stress, or in implant in proximity with other metals such as amalgam restorations, gold alloys or chromium-cobalt alloys, may cause the corrosion of titanium implants. The micro particles or ions of titanium metal released in and around the peri implant tissue and also in proximity of periodontal ligament of adjacent tooth to the implant can lead to inflammatory reactions. Macrophages that get activated by titanium will secrete cytokines which are responsible for allergic reactions. Titanium ions (haptens) that are released by surface layer degradation may combine with endogenous proteins to form antigenic molecules due to their high affinity with protein. These antigenic molecules (the allergen) are captured by langerhans cells, related to T-lymphocytes. It produces Type IV allergy, known as delayed-type hypersensitivity reaction (Juliana, 2011).

Many types of allergic reaction takes place following ingestion of metal ions into the skin and/or mucosal contact and also from implant materials due to release of corrosion byproducts. These metal ions form various complexes with neighboring tissue and immediately react with proteins and act as allergens that result in hypersensitivity type of allergic reactions. Allergies have presented with signs of rashes, itching, eczema, urtecaria, edema, pruritus and redness of the skin and mucosa, the reaction might be localized or generalized. Rarely some cases results in more serious problems such as impaired healing of fractures, atopic dermatitis, pain, weakening of implants and necrosis. In the field of implants, the appearance of non-keratinized, edematous, proliferative hyperplastic tissue and facial erythema have also been found (Juliana, 2011).

With the recent trends, advances and popularity of treatments options like early loading of implants, it is difficult to assume the outcome and success of implants with early loading protocol and also to consider the effects and reactions of electrolytic signals on the stages of osseointegration as well as on long-term success of implants. Various new techniques and methods have been introduced in recent years to reduce failure rates of implant due to corrosion byproducts: newer composition of metallic alloys that are available in most improved and biocompatible form, the physical, chemical, mechanical and corrosive properties of the materials used in manufacturing of dental implants with better surface modifications have been introduced to neutralize the surface reactivity of the dental implant. However, a fundamental rule of understanding the consequences of abnormal electrical waves formed by corrosion byproducts on the development and growth of bone cells and peri implant tissues is necessary in treatment of affected individuals who give a history of allergy to corrosion byproducts of dental implants (Gittens, 2012).

Conclusions

Corrosion of metals in the body is one of the major complication that results in aseptic failure of dental implants. The physical, mechanical and chemical properties of the metal form some of the very important and essential criteria for selection of implants; alternatively development of new implant materials is out most important. The biggest improvements in field ocould be made by selective better material selection, design, and quality control to reduce, or possibly eliminate corrosion in implant devices.

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