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Corrosion and fracture analysis in screws of dental implants prostheses. New coatings

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ABSTRACT

The oral cavity has some characteristics of high concentration in mineral salts, enzymes, proteins and cells, which modify the implant-abutment-prosthesis unity. The protection of the dental implant abutment screw for corrosion and the improvement in its structure are one of the keys of success in our new restorative treatment in the long term. The titanium and its alloys release to the oral medium ions, which are not thought to be health damaging. However, thanks to its resistance to corrosion due to the layer formed with inert oxide the layer remains constant. In spite of this fact, there are phenomena which produce fatigue striation. The increase in the amount of mechanic failure and the appearance of microcracks make us review old concepts. Mechanisms such as the protein absorptions and micro-cracks propagation of the structure produce corrosion phenomena which can result in failure. The use of silver and copper nanoparticles for the dental implant abutment screw coating inhibits partly the production of corrosion product and the increase of elements such as sulfur, chlorine and sodium, which are the products that increase the microcracks of the original machining of the screw.

1. Introduction

In the last few decades we have seen an important growth in the different fields of medicine, thanks to the increase in technological media and a better communication resulting from “the information society”. In the case of implantology, there is a potential market which only in the USA more than 200 million people have lost a tooth or more, and it is considered that the 40% of the population over 40 own edentulous spaces [1]. This makes them candidates for a replacement treatment with dental implants [2].

The assembling formed in the implant complex must be understood after analyzing the multiple forces to which are subject, although there are several commercial designs. The complex which the implant forms is primarily the union of various components which form a solid union through a screw [3]. This process of assembly generates forces in the implant complex and it creates a functional union which allows the system of implants to be able to carry a dental prosthesis of whatever type.

An abutment is joined to the implant through a prosthetic screw [4,5]. This one is tightened applying the torque clench to the head of the prosthetic screw, which controls in that moment the forces that are transmitted during the interphase abutment-implant through the spires surface once the prosthetic implant is tightened to a specific torque according to each manufacturer's instructions.

It has been sufficiently demonstrated by theoretical models that we can protect the overload union to avoid the screw fatigue. An optimal overload should induce stress in the union which is from 60% to 70% [6,7] of the maximum force of the material deformation

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with which is manufactured the screw that anchors the abutment to the correspondent implant. It affects in the same way the spires and the space prepared on the head of the implant to transmit the force in the preload.

Variables occur such as geometric factors (i.e. the angles which the spires formed and the dimensions of the complex implant-abutment-crown), the properties of the materials (module of elasticity, Poisson coefficient) [8,9], as well as the environmental conditions which interact with the friction surfaces, and it varies according to the lubrication which joins the screw and the inner spires of the implant [10].

The loads that are produced in the oral cavity by our implants are dependent on a complex chemical and physical equilibrium of the different components that compose the oral medium. This is very corrosive and has a high concentration of mineral salts. Also, the concentration of enzymes and the interaction produced in vivo with the cells and proteins that come from the saliva affects the surface of the components of our implants [11]. The fatigue of the materials produced by the load is increased by the microstructural changes that are produced on the titanium surface. The research on the fracture patterns after submitting the implants and the prosthetic screws with cyclic effort shows that the biologic environment encourages the extension of the existing microcracks on the titanium surface.

The passage of bacteria and saliva components has been widely studied in spite of the fact that trading houses make an effort to improve their adjustments. Studies of microfiltration show how especially in dynamic conditions passage of molecules, bacteria and fluids exist to the inner part of the components of the implant which implies corrosion. These studies of permeability are carried out with the application of gas in the interphases which allows seeing the zones more likely to filtering and the route of fluids [12] and the convenience of the new internal connections that will improve the universal external connections type “Brånemark” used in the implants of this study [13].

Saliva is a fluid which is produced and spread into the oral cavity by different organs called salivary glands. It is a complex secretion that comes from salivary glands in a 93% of its volume and the smaller in the remaining 7% [14,15]. It performs very important functions in the oral and general health maintenance of people, among them: lubrication, antimicrobial action, buffer capability of the pH of the oral cavity and dental plaque, re-mineralization, mastication, digestion and taste. In the composition of this fluid we can find different molecules, and inside them proteins stand out, which are involved in most of the saliva's functions.

Proteins are a very important component in the phenomena of corrosion as their presence can inhibit or accelerate the process of corrosion. They act in a different way according to the metals, being the characteristics of the surface, the characteristics of the absorption of proteins, the interaction between the protein molecules and the electrolytic solution to produce organic complexes or the anionic or cationic transport according to the biologic environment, some of factors that condition its corrosive action [16]. When H ions are free to interact with electrons, the pH drops significantly, and active metal dissolution can occur. Other events, such as pitting attack, surface delamination and etching of Ti implant surfaces, give indications of degradation induced by a very acidic environment [17].

The coatings of the prosthetic screws are an effective tool to prevent the loss and fracture of themselves. Under cycling loading [18], the growing of the resistance to the fracture due to the improvement of its properties in the stretching and the hardness has made us consider this factor as important and it is one of the key of this research but from the perspective of corrosion (See Fig. 1).

The phenomena of corrosion of the elements which compose the complex implant-abutment-crown should be analyzed and controlled since the authors suggest that the biofilm layer that is produced on the implants surface affects the properties of the implant-prosthetic components [19] The biofilm is formed by different bacterial species, and the first colonies are the ones corresponding to the bacteria that come from the oral exposition through saliva as the “*Streptococcus sanguinis*” and secondarily “*Lactobacillus salivarius*” [20]. This focuses the main part of the investigation of the weakening process due to a bacterial cause from titanium over these two species of early colonization [21].

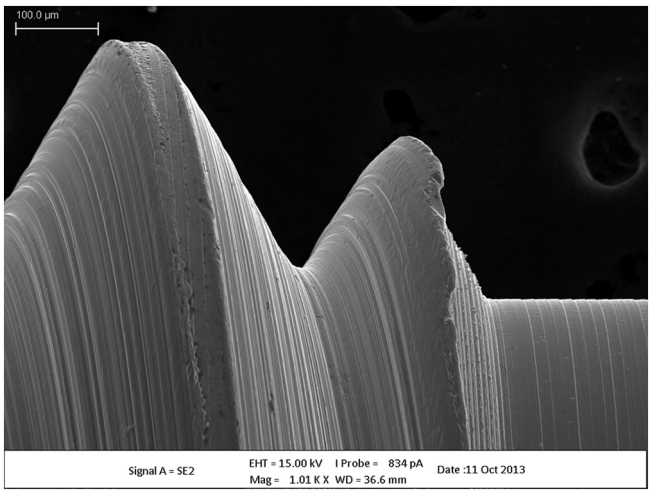

Fig. 1. Screw bad manufacturing. It propitiates the expansion of micro-cracks due to bacterial attacks on the surface, so the new coatings could improve the resistance against that.