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Review Article

A REVIEW ON CORROSION OF DENTAL ALLOYS

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ABSTRACT
For regaining the normal functions of the dentition, artificial materials are often used to re-establish the missing part or structure, these are known as dental materials. Metals and alloys, e.g., gold alloys are usually used dental materials, due to their high strength and other advantageous properties. Many substitutes for gold alloys have also been employed and some of them possess superior mechanical properties. Growing knowledge about interaction of dental materials with oral tissues has resulted in evolution of high performance dental materials to meet the various requirements of the oral environment. Leaching of metallic ions and food habits are the main cause of corrosion of metallic dental implants and restorations. Therefore, corrosion has been considered as the most vital factor in the selection of metallic materials, hence it deserves special emphasis and must be evaluated in ever-changing oral environment.

Key words:- Dental; Metal alloys; Corrosion; Pitting; Leaching; Cavitations.

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INTRODUCTION
In dentistry the most important factors affecting the choice of dental metals and alloys are the biocompatibility, mechanical properties, workability and resistance to tarnish and corrosion [1]. Therefore metals and alloys which are to be used in the mouth should withstand the moist, temperature changes and pH changes which occur during the breakdown of foodstuffs. Unfortunately foods show different pH levels and most of them shows pH levels below 7 which accelerate the corrosion rates of metals and alloys.

The corrosion properties of metals and alloys depend upon their compositions, their electrode potentials, to the stress over the metals and to the surface roughness. In addition to these factors related to metals, corrosion processes are also dependent on the specific characteristics [2] of different oral environments (saliva, dental plaque, bacteria, gastric acid reflux, etc.) and the acidity, oxidation level, temperature, velocity of mixing and the inhibitors of media also affect the corrosion process.

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DISCUSSION
Corrosion is defined as the destruction or deterioration of a material because of reaction with its environment. Also, corrosion [3] shows the oral

environment as a chemical or electrochemical process through which a metal is attacked by natural agents, such as air and water, resulting in partial or complete dissolution, deterioration, or weakening of any solid substance. Fontana and Jones [4] have classified corrosion. It is important to know that the purity, casting and melting techniques also affect the corrosion behavior of alloys.

Uniform or general corrosion:

This corrosion is defined as a chemical or electrochemical reaction that proceeds homogeneously over the entire exposed surface or over a large area. This produces the normal flux of ions from an implant, which can interact with tissue.

Nagai et al [5]. concluded that the spherical-particle amalgam is more resistant than the conventional amalgam after testing the corrosion resistance of some alloys. The corrosion resistance of conventional alloy, spherical-particle alloy, and dispersion-phase alloy was clinically evaluated and it was concluded that dispersion-phase alloy offered more resistance to corrosion. Corrosion process released tin ions from tin based alloys to form 2 (Sn8Hg) phases, which then reacted with nonmetallic ions in saliva to produce tin salts. Copper and zinc alloys exhibited large corrosion in non-self-cleaning sites in the mouth. Nickel–chromium alloys showed superior corrosion resistance in the oral cavity, whereas, copper–zinc alloy (Progold) showed significant corrosion when it was immersed in a chloride solution .But, corrosion resistance of low gold casting alloys decreased in chloride solutions using potentiodynamic polarization measurements than with other conventional gold alloys. The effect of chloride ions was observed on the corrosion behavior of five silver–palladium dental casting alloys in a 1% NaCl solution using potentiodynamic polarization measurements and microstructure analysis.

Galvanic or two-metal corrosion

This occurs due to the galvanic coupling of dissimilar metals. Less corrosion-resistant metals become anode and usually corrode. The Dentist knows about the risks of this type of corrosion and prefers homogeneous metals with respect to metallurgical state and chemical composition. Researchers reported that the galvanic current could have a harmful effect on soft tissues. However, this was contradicted by, as there is no difference between gum tissues adjacent to and away from such on clinical observations. Schoonover and Souder reported that because of an electrochemical reaction, gold restorations were corroded by mercury released from amalgam fillings. Some investigated the corrosion of gold and amalgam placed in contact and observed that silver-colored stains formed on gold inlays surface that had got into contact with fresh amalgam mix or fillings. Researchers demonstrated that the 2 phase (SnxHgy) of the silver amalgam was most susceptible to breakdown by electrolytic action. According to Jorgensen, marginal breakdown and ditching seen in dental amalgams in the mouth is due to concentration cell currents occurring along the margins of amalgam restorations. Dental amalgam subjected to high pressure resulted in the complete disappearance of 2 phases by the transfer of tin to 1 phase. The degradation reactions between oral fluids and brazed joints were mostly attributed to galvanic coupling; this is due to differences in the composition of castings and brazed alloys. Shigeto et al. concluded that in soldering Ni–Cr alloy, use of gold solder and a high-resistance Ni–Cr alloy should be chosen for corrosion resistance. They also studied corrosion properties of solder joints by analyzing corrosion pattern of dental solder and dental nickel–chromium alloy and confirmed the previous findings. Palaghias et al. reported that in vivo corrosion resistance of the titanium pins was better to that of gold-plated stainless steel pins.

Crevice corrosion:

Crevices on the material surface cause the regions of stagnant solutions, and attack the material. This attack is defined as crevice corrosion. Crevices are unavoidable with surgical implants where a screw or plate contacts the bone. The local flux of ions is drastically enhanced at crevice sites and tissue impregnation follows. The contact region of a screw or implant material can form the crevice. In the small space the liquid and oxygen exchanges are severely limited, and surface in the crevice undergoes active corrosion and cause further deterioration of the milieu [6]. Failures in soldered joints, especially when stainless steel is soldered with silver solder is due to corrosion. In this case, either the residual fluoride flux or the difference of the metals results in crevice corrosion. Crevice corrosion of silver soldered stainless steel was studied and established its convenience by using 316 L stainless steel.

Pitting:

It is a form of extremely localized attack that results in holes on the surface. The localized breakdown of the protecting passive layer causes pitting and this is termed a ‘bad habit’ of aluminum and low-grade stainless steel. Zavanelli et al [7]. studied corrosion–fatigue life of pure titanium and Ti–6Al–4V alloys in different storage environments, and observed significantly reduction of fatigue life when solutions were present, this may be due to initiation of corrosion pits caused by superficial reactions.

Intergranular corrosion:

Due to more reactive nature of grain boundaries, intergranular corrosion occurs adjacent to grain boundaries with relatively little corrosion of grains. This type of corrosion occurs due to the inhomogeneity and mainly technological errors. It has been demonstrated that heating 18-8 stainless steel between 400 and 900 ◦C may negate its resistance to corrosion. This corrosive tendency was attributed to the precipitation of chromium carbide at the grain boundaries at elevated temperatures.

Selective leaching:

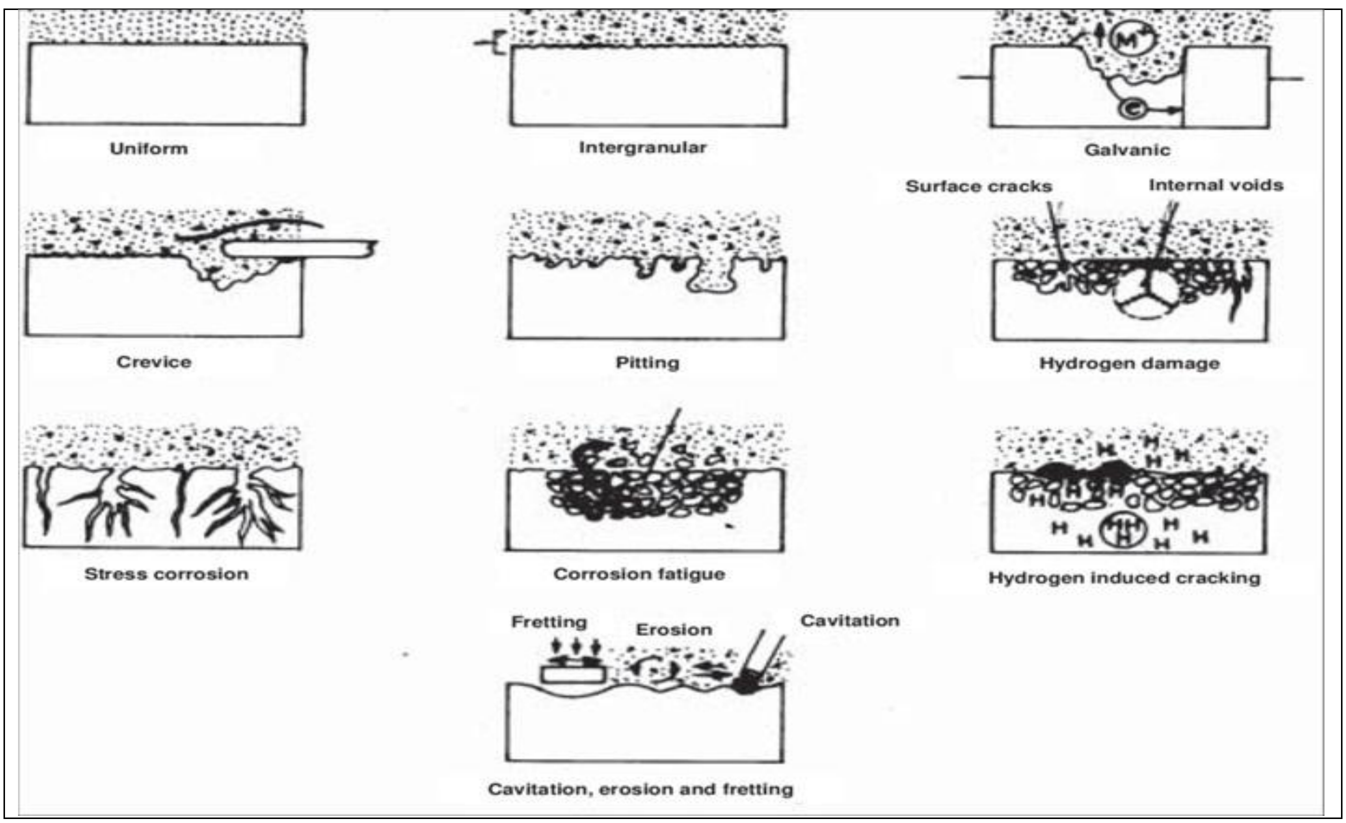
It is the process of removal of one element from a solid alloy by corrosion process. This process is generally not that important in dentistry. Tai et al [8]. studied leaching of nickel, chromium, and beryllium ions from base metal alloy in an artificial oral environment and showed that nickel and beryllium metals were released both by dissolution and occlusal wear.

Erosion corrosion

Erosion corrosion is the acceleration or increase in rate of deterioration or attack on a material because of relative movement between a corrosive fluid and the material surface. It includes cavitation damage and fretting corrosion. Cavitation damage is not important in dentistry. Fretting is described as the corrosion occurring at contact areas between materials under load subjected to vibration and slip. During insertion of an implant, some degree of abrasion between fixing screws and implants or between tools (screw drivers, grips, etc.) and implants is bound to occur. Another source, more or less continuous, of abrasion on implant structures, functional loading, which induces relative movement between the material (screw hole) and the screw head. In fact, the (local) elasticity of the implant differs from that of the tooth material causing fretting corrosion. The mechanical component of fretting, i.e., the rubbing movement, disrupts the protective surface films and removes metal particles. This action stimulates the chemical activities at the surface, leading to oxidation, or active corrosion, or repassivation as a result of the electrochemical aspect of the process

Stress corrosion

Stress-corrosion cracking refers to cracking caused by the simultaneous presence of tensile stress and a specific corrosive medium [9]. This can dangerously impair the mechanical integrity of an implant. During mastication, restorations are subjected to heavy compressive shear, and bending forces. Also, burnishing of surfaces sometimes results in localized deformation. Thus, an electrolytic cell is formed between the stressed and unstressed metal portions. Grain boundaries of stressed metal are most vulnerable to corrosion. The failure of the soldered joint or the flaking away of a thin margin of gold occurs due to stress corrosion. In mouth, the process of corrosion may be of several types. So, the chances of correlating in vivo clinical results with in vitro results seem less plausible.



CONCLUSION

The nature of dental metal alloys plays a major role in the initiation and propagation of corrosion. Though a large number of investigators have made efforts to investigate corrosion of dental materials, generalized correlations are difficult due to wide variation in the experimental conditions used. Therefore, corrosion free/least [10] corrosive metal alloys should be used for the artificial tooth and repair of the cavities for good health.

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