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Review

Corrosion of alloys used in dentistry: A review

Deepti Upadhyay [a,*], Manoj A. Panchal [b], R.S. Dubey [b], V.K. Srivastava [c,1]

[a] *Department of Chemistry, UP College, Varanasi 221001, Uttar Pradesh, India*
[b] *Department of Chemical Engineering & Technology, Center of Advanced Study, Institute of Technology, Banaras Hindu University, Varanasi 221 005, Uttar Pradesh, India*
[c] *Department of Mechanical Engineering, Institute of Technology, Banaras Hindu University, Varanasi 221 005, Uttar Pradesh, India*

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Abstract

For regaining the normal functions of the dentition, artificial materials are often used to restore the missing part or structure, these are known as dental materials. Metals and alloys, e.g., gold alloys are commonly used dental materials, due to their high strength and other desirable properties. Due to high cost of gold, alloys are being increasingly used in dental applications. Many substitutes for gold alloys have also been employed and some of them possess superior mechanical properties. Increasing 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 important factor in the selection of metallic materials, hence it deserves special emphasis and must be evaluated in ever-changing oral environment.

The main objective of the present review is to describe the importance of corrosion of dental metals and alloys. Different dental materials together with oral environments and various types of corrosion have been described and related reported findings have also been reviewed briefly.

Keywords: Dental; Metal alloys; Corrosion; Pitting; Leaching; Cavitation

Contents

* Corresponding author. Tel.: +91 542 2368427; fax: +91 542 2368428.
E-mail addresses: upadhyay_deepti@rediffmail.com (D. Upadhyay), vk_sa@yahoo.co.in (V.K. Srivastava).
[1] Tel.: +91 542 2368157; fax: +91 542 2368174.

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1. Introduction

The field of dental materials is highly catholic in nature, in the sense it covers a wide variety of materials from fairly exotic resin systems, elastomers, metals, alloys to ceramic materials, and many others. Metal alloys have high strength and have been found to be competitive among other dental materials. For selecting a material for dental application, it is necessary to remember that the choice of material depends on a number of factors like corrosion behavior, mechanical properties including strength and fabricability, cost, availability, biocompatibility, and aesthetic values. The corrosion behavior of metallic materials usually is the most important property because of biocompatibility and cytotoxicity of the products of the corrosion process. However, from aesthetic considerations, appearance is the most important factor to be considered. The mechanical properties of the materials are equally important even though the materials may have enough corrosion resistance. Cost and availability are also important for the selection of the materials.

To better understand the effect of corrosion in the mouth, it is essential to become familiar with metals and alloys normally used, their composition, the environment in which they must function and also its effect. The main interest of the present article is to review briefly the corrosion behavior of various dental alloys as reported by various research workers.

2. Metals and alloys

Metals have been used as dental materials for over a century. Generally, most metals are strong enough to withstand maximum possible oral forces. Despite the fact that metals showed deterioration, before the availability of techniques to evaluate materials performance in biological systems, other high performance materials could not be developed to improve implant life and properties. Advent of innovative technologies and aseptic surgical procedures enabled researchers to ascertain the reason of failure of dental materials and consequentially development of high performance and cost effective materials.

The irritability or cytotoxicity of a metal to cells is closely related to its location in the periodic table. Gold is the commonly used metal because of its high resistance to tarnish and corrosion [1]. In its pure form, gold is too soft for most dental applications. Under certain circumstances where mechanical properties are not important, pure gold is used in the form of gold leaf, powdered gold, and crystalline gold. Although no other metal can withstand the fluctuating oral conditions like gold but the alternative alloys available in the market also possess the properties approaching near to the ideal properties needed for dentistry. A variety of alloys with physical properties suitable for specific applications have been developed to meet the requirements of various functions and properties. A general classification of dental materials, their class and broad application areas are listed in Table 1 and their compositions are given in Table 2 [2,3].

3. Oral environment and effects on metals and alloys

Structures in the mouth are constantly exposed to an ever-changing physical and chemical environment that includes temperature and components like saliva, salts, foods, liquids, and drugs. Plaques and food adhere to teeth and filling materials, which means several forms of bacteria and their products are always present inside mouth. Mechanical forces also vary with respect to the type of food consumed, temperament of person, and location in the mouth.

The average biting force of a person with natural dentition is approximately 77 kg in the posterior part of mouth. It represents approximately 0.193 GPa on a single cusp of molar tooth. Similarly the temperature in the mouth fluctuates rapidly. When one drinks coffee immediately after ice cream, change in temperature is as great as 65 °C and pH also changes widely in the mouth. Moist environment in the mouth also varies and affects dental materials. Under these circumstances, corrosion of metals and alloys in the mouth is expected and it does occur. Some experimental observations reported by different researchers are summarized below.

Laing et al. [4] observed that the tissue reaction was proportional to the amount of constituent elements released by corrosion of a pure metal or alloy. On the other hand, intermetallic compounds, e.g., Ag–Sn and Cu–Sn have oxidized films on their surface protecting them from corrosion in living tissue [5]. Also, electro-deposited gold is provided with a passive protective surface [6]. Several corrosion products of metal alloys like nickel carbonyl, nickel subsulfide, and nickel sulfide have been shown to produce carcinogenesis [7,8]. The presence of components of the posts in dark gingival discolorations has been reported adjacent to restorations [9]. Many heavy metals likes nickel, chromium, and beryllium are classified as carcinogenic, hazardous, and priority toxic pollutants

Table 1
Types and classes of metallic dental materials and their applications [2,3]

S. no.	Type	Class	Principal application
1.	Amalgam	Low copper	Posterior restoration of teeth
		High copper	Posterior restoration of teeth
2.	Noble alloys	Gold (non-heat-treatable)	Restoration of single teeth
		Gold (heat-treatable)	Fixed bridges
		Palladium–silver	Restoration of single teeth
3.	Base alloys	Nickel	Restoration of single and missing teeth, partial denture frameworks
		Cobalt	Partial denture framework and implants
		Iron	Orthodontic appliances and endodontic instruments