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Effects of the sources of calcium and phosphorus on the structural and functional properties of ceramic coatings on titanium dental implants produced by plasma electrolytic oxidation

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ABSTRACT

Plasma Electrolytic Oxidation (PEO) is as a promising technique to modify metal surfaces by application of oxide ceramic coatings with appropriate physical, chemical and biological characteristics. Therefore, objective of this research was to find the simplest settings, yet able to produce relevant bioactive implant surfaces layers on Ti implants by means of PEO. We show that an electrolyte containing potassium dihydrogen phosphate as a source of P and either calcium hydroxide or calcium formate as a source of Ca in combination with a chelating agent, ethylenediamine tetraacetic acid (EDTA), is suitable for PEO to deliver coatings with desired properties. We determined surface morphology, roughness, wettability, chemical and phase composition of titanium after the PEO process. To investigate biocompatibility and bacterial properties of the PEO oxide coatings we used microbial and cell culture tests. The electrolyte based on $Ca(OH)_2$ and EDTA promotes active crystallization of apatites after PEO processing of the Ti implants. The PEO layers can increase electrochemical corrosion resistance. The PEO can be potentially used for development of bioactive surfaces with increased support of eukaryotic cells while inhibiting attachment and growth of bacteria without use of antibacterial agents.

1. Introduction

Artificial osseous/dental implants have become a useful and reliable standard treatment option to replace tooth loss, as well as to repair bone defects [1–3]. The majority of the implants nowadays are fabricated using titanium and its alloys. Other materials, including non-metallic ceramic implants using zirconia (zirconium dioxide, ZrO_2) also show promises, but still lack long term clinical data to support their use despite showing advantages in short term applications [4,5]. Titanium is an inert, light and mechanically stable metal, highly resistant to corrosion in aggressive environments, including conditions prevalent in the human body, and is considered to be biocompatible. It has a very high weight-to-strength ratio, and is generally not immunogenic [6]. The main factors which determine the stability of the implant are i) the level of osseointegration, meaning ability to establish the direct firm contacts of the bone cells with the surface of the implants [7] and ii) the ability of the surface of the implant to resist bacterial colonization and formation of biofilms [8]. Another important factor is to maintain bone-to-implant contact over time during many years after surgery without intensive bone loss [9]. Certain conditions such as smoking, hypertension and diabetes negatively affect the success of dental implants [10]. Successful long time implant survival under such challenging

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