Titan-based alloys

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Titan-based alloys are the most-utilized materials in dental implantology, due to their physical and chemical properties. The various components of the oral environment should be considered in order to obtain a good stability of dental reconstructions. Salivary ions, proteins, enzymes, and microorganisms of the oral biofilm, may interact with and influence the implant's corrosion process. Peri-implantitis is a multifactorial process which needs to be properly addressed in order to prevent secondary implant failure.

Keywords: titanium alloy ; corrosion ; peri-implantitis ; oral environment

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1. Introduction

Since their introduction by Brånemark in the 1960s, oral implants have become an increasingly used option in dental practices for restoring dento-maxillary functions by replacing teeth that were lost through trauma or various pathological processes [1][2]. The clinical results [3] and prognosis [4] of implant therapy are influenced by the patient's alveolar bone, regulated by local and systemic factors, but also by the physical and chemical properties of the implanted materials [5]. These properties include the implant microstructure and the composition and characteristics of its surfaces [6]. Thus, an ideal implant material should be biocompatible and resistant to corrosion, wear, and fractures [7][8]. With such requirements, Ti alloys are the most-used dental materials for implant works [9].

Titan-based alloys are the most utilized in dental implantology due to their stability in the human physiological environment, on account of the native amorphous oxide on their surface [14][15]. The oxide layer on the surface of the implant plays a crucial role in its stability, preventing the release of metal ions into the surrounding areas. As such, the layer of native oxides arising from the alloy's elements prevents the dissemination of corrosion processes from the surface of the biomaterial [16][17]. Discontinuities in the oxide film may occur due to the actions of active oxygen species, proteins, cells, or organic ions [18].

To obtain a good stability of dental reconstructions [10], all the factors that contribute to the oral environment should be considered [11]. Salivary factors, microbial biofilms, and factors related to reconstructions are part of a unique, dynamic, and complex system that influences short- and long-term prosthetic implant therapy [12][13].

2. Data

Implant failure may be influenced by mobility, wear, or the exposure of the implant to the oral cavity environment [19]. Peri-implantitis is a chronic pathological microbial process [20] that affects the soft tissue and surrounding bony areas of an osseointegrated dental arch implant and leads to bone resorption [21]. Peri-implantitis may favor implant rejection, increasing the accumulation of bacterial biofilm on the implant surfaces and initiating an increased number of inflammatory cells in the subepithelial conjunctive tissue [22][23]. Systemic conditions, such as HIV, may cause an increase in peri-implant infections and slightly worse results of the implant rehabilitation, which may be hindered by heavy smoking, but apparently not by oral hygiene [24][25][26].

Secondary implant failure related to peri-implantitis may be predicted using the plaque index (PI) and the presence of bleeding on probing (BOP) and of pocket probing depth (PPD), which have proven to be significant risk indicators [27]. The treatment of peri-implantitis may be conservatory, but surgery is an option, employing resection or regeneration [28]. Preventive measures when implanting, such as employing a partial thickness flap, may allow an adequate development of keratinized tissue around the implant, increasing implant survival [29].

Bacteria may colonize the implant's rough surface and facilitate the adherence of other colonizers, which causes a time-dependant aggression on the implant, with detrimental effects such as pitting corrosion after one month, and flexural strength decline after three months [30][31]. The colonization of the peri-implant sulcus by Gram-negative anaerobes alongside other factors, such as poorly controlled diabetes, smoking, implant design, and mechanical stress, creates an inflammatory environment facilitating loss of bony support and ultimately leading to implant failure [35]. The bacterial profile seems to correlate with the degree of inflammation and the prognosis of the implant, however, the surface structure of the implant is also an important factor, due to the attachment affinity of some bacteria to specific implant surface types [36]. The inconsistently reported prevalence of peri-implantitis seems to confirm that it is a complex multifactorial process, and the correct identification of bacterial pathogens to peri-implantitis may help limit the disease severity [37].

Sulfur is an important component of proteins and is found in high quantities in the oral cavity in the composition of filaggrin [38]. Filaggrin (filament aggregating protein) is a filament protein connected to keratin fibers in the epithelial cells. In the epithelial tissue, these structures are found in keratohyalin granules in the granulous layers [39]. This protein is essential in the homeostasis of the epithelial tissue. In the corneous layer, filaggrin monomers are part of the skin barrier structures. Alternatively, these proteins may interact with keratin intermediary filaments. The impact of the keratinized gum on dental implants has long been debated and is a subject of controversy, however, most studies underline the importance of an adequate keratinization area around implants [40][41].

Some studies have shown an association between the lack of keratinized tissue and slight bone loss [42], with a higher accumulation of bacterial plaque and increased soft tissue retraction [43]. Alongside these clinical signs, an increased bleeding on probing index was recorded, noting a significant increase in gingival inflammation [44]. The discontinuity of the oxide film exposes a fragment of the alloy surface to the external environment, leading to a release of metallic ions and the initiation of alloy corrosion. The intensity of the galvanic effect is influenced by the potential difference between the metals that trigger this process [45]. In dental implantation, the exposure is to the oral environment and the presence of saliva. Salivary ions, such as chloride, sodium, calcium, and potassium, but also proteins, enzymes, and microorganisms of the oral biofilm, may interact with and influence the corrosion process [46][47].

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