# Surface modification of dental implants

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Dental implants are widely used in the field of oral restoration, but there are still problems leading to implant failures in clinical application, such as failed osseointegration, marginal bone resorption, and peri-implantitis, which restrict the success rate of dental implants and patient satisfaction. Poor osseointegration and bacterial infection are the most essential reasons resulting in implant failure. To improve the clinical outcomes of implants, many scholars devoted to modifying the surface of implants, especially to preparing different physical and chemical modifications to improve the osseointegration between alveolar bone and implant surface. Besides, the bioactive-coatings to promote the adhesion and colonization of ossteointegration-related proteins and cells also aim to improve the osseointegration. Meanwhile, improving the anti-bacterial performance of the implant surface can obstruct the adhesion and activity of bacteria, avoiding the occurrence of inflammation related to implants.

Keywords: dentistry ; dental implants ; surface modified ; osseointegration ; bacterial antagonist ; functional coatings ; active surfaces ; coating performance

## 1. Osseointegration for Dental implants

Dental implants have been proven to have predictable and reliable therapeutic effects for repairing lost teeth [1][2][3]. Although dental implantation has a high success rate and survival rate, it is still difficult to avoid implant failures due to some risk factors [4]. Many reasons would result in failed dental implants, including implant-, clinician-, and patient-related factors, infection, and foreign body reactions, which may accelerate alveolar bone loss [5] The loss of alveolar bone, usually accompanied by the accumulation of microbial plaque and bacterial infections and is primarily associated with peri-implantitis, is the chief cause for implant failures [6]. As a result, maintaining stable ossteointegration and avoiding bacteria-related alveolar bone loss are of great significance in dental implantation. Ideal ossteointegration is ensured by direct, structural and functional contact between bone tissues and the surface of an implant loading occlusal force [7]. The productive osseointegration is crucial to maintain long-term stability between implants and newly-formed peri-implant bone, which helps to shield implants from soft tissues [8].

## 2. Implant surface design

Dentists designed implants with different sizes, lengths, shapes, threads, and surface treatments to deal with different alveolar bone conditions in the field of implantology in the past 50 years [9]. The implant surface design creates a safe side to prevent most of the oral bacteria, and even have a sterilizing effect, and an optimized surface of implants has been attached more and more important to among those designs in an optimal process of osseointegration. As early as the 1990s, Buser et al. firstly compared the influences of surface characteristics on bone ossteointegration among 5 different surfaces of titanium in a preclinical study [10]. So far, many scholars have devoted to promoting the engineering designs of implant surface, in order to optimize titanium implant-related osseointegration by improving a series of physiological reactions such as attachment, proliferation, differentiation, matrix synthesis and calcification of osteoblasts in the peri-implant alveolar bone [11]. Currently, the zirconia implants have received widespread attention to white-colored surfaces, which are considered esthetically superior to the gray-colored titanium [12]. However, non-metallic surfaces require some special modification methods to promote osseointegration. Generally, modifying the properties of implant surface, for instance, roughness, free surface energy, and chemical composition, is an effective method to achieve fast healing and better osseointegration [13]. Also, micro-nano structural modification of the implant surface, which could enhance the hydrophilicity and bone conductivity of the implant, and reduce the stress conduction, is a research hotspot in the field of implantology. Additionally, various methods of surface coatings to enhance the biological activity of implant surface, which mostly are involved in interdisciplinary fields of biology and materials, are rapidly developing. These methods could optimize the implant surface features, including the chemical composition, charge, wettability, and roughness of surfaces, and can finally affect the interaction with bacteria [14]. Active molecules grafting onto the implant surface is the most representative and potential modification method, which could reduce foreign body reaction (FBR) and improve osseointegration in some preclinical researches [15]. Nonetheless, how to avoid the inactivation of these active molecules in body fluids is a thorny problem in translational research. Therefore, in order to reduce the incidence of peri-implantitis, it is necessary to exploit the advanced implant surface coatings, which could both enhance the osseointegration process, as well as prevent or inhibit bacterial colonization.

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