Free Session

Surface modifications

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Controlling bacterial adhesion to titanium surfaces: new strategies for surfaces with tailorable anti-adhesive/antibacterial properties

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Introduction: Bacterial contamination is a serious problem in different fields (from everyday life to aerospace) and it becomes critical in biomedical implants: because of increasing bacterial resistance to antibiotics, the development of alternative antibacterial solutions is a high medical need. Implantable biomaterials are frequently associated with infection; a limited colonization and, eventually, a localized active antibacterial action are a challenge for reducing the risk of implant associated infections.

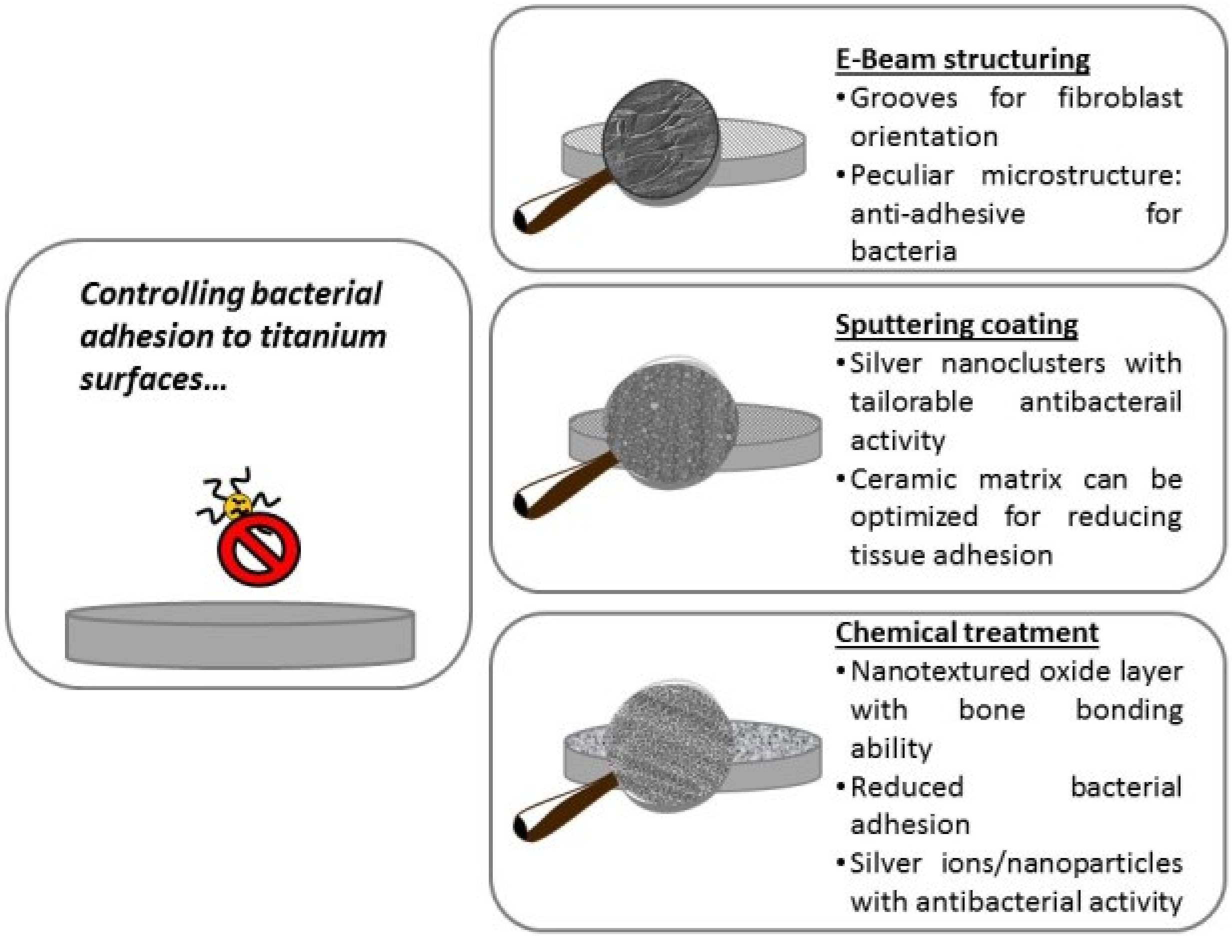
The present research summarizes different strategies aimed at reduction of bacterial adhesion to titanium surfaces moving from simply anti-adhesive surfaces to anti-bacterial and even to bioactive and antibacterial ones.

Experimental methods: Titanium and its alloys (mainly Ti6Al4V) were used as substrates.

Different surface treatments were considered in order to improve the biological response of metallic surfaces in specific applications and simultaneously reduce bacterial adhesion. They are briefly summarized in the following Table

- Electron beam structuring has been investigated for the realization of aligned micro-grooves aimed at fibroblast alignment for soft tissue healing. The process induces peculiar surface microstructure and crystallographic structure which can affect bacterial attachment [1]
- Sputtering coating: silica, alumina and zirconia coatings containing metallic silver nanoclusters were deposited on titanium surfaces in order to obtain anti-adhesive coatings for temporary fixation devices with tailorable antibacterial activity [2]
- Bioactive nanotextured titanium oxide layers doped with silver ions/nanoparticles were obtained onto titanium surfaces by means of thermo-chemical treatments in order to combine bioactivity and antibacterial activity in bone contact applications [3, 4].

Image:



Results and discussions: As first, all the produced surfaces have mean surface roughness lower than 0.2 µm, reported in literature as threshold to avoid an increase in bacterial adhesion [5] compared to the mirror polished uncoated controls. Moreover, despite of absence of an active antibacterial agent, both EB-structured and nano-textured surfaces are able to reduce bacterial adhesion due to their peculiar microstructure and nanotexture [1, 6]. This strategy is of particular interest because poorly explored: it can be challenging for surfaces with limited bacterial contamination without the introduction of any antibacterial compound. In presence of a high number of bacteria, the anti-adhesive activity is mainly concentrated in the first days, due to the absence of an active bactericidal element. The introduction of silver allows to induce a tailorable antibacterial activity (in fact the amount of Ag can be modulated both in sputtering coating and in thermo-chemical treatments) with limited risk of resistance development. The most challenging point for Ag containing surfaces is a proper modulation of Ag content in order to have simultaneously high antibacterial activity and biocompatibility. The antibacterial activity of these surfaces is based mainly on a ion release mechanism and its duration is strictly related to duration of ion release.

Conclusions: Surface modification of titanium surfaces is a versatile strategy in order to obtain anti-adhesive or antibacterial surfaces of interest in the biomedical field. Different processes can be considered depending on the specific application; the control of bacterial adhesion can be coupled with modulation of the interaction between the metallic surface and the biological environment.

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