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BASIC RESEARCH

Improvement in wettability and crystallinity by reactive plasma on nanostructured titanium surfaces for implants

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Background: Studies have already proven that micro and nanoscale changes allow optimizing the physicochemical properties of titanium (Ti) implants. Several superficial treatments allow modifying cell growth and adhesion rates leading to rapidly osseointegrated implants. Hydrophilicity is a very relevant factor in relation to bone healing speed around Ti. Therewith, recently UV-light and plasma treatments have allowed surface hydrophilicity to take new heights, but this beneficial effect is short-lived.

Aim/Hypothesis: The aim of this study was to investigate methodologies post-anodizing treatment on the titanium surface, to generate and maintain high surface hydrophilicity along with high biocompatibility and bone cell adhesion.

Materials and Methods: For the present investigation, anodized surfaces were developed on pure Ti discs and characterized employing Scanning electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) for morphology; Atomic Force Microscopy (AFM) for roughness; and Rutherford Backscattering (RBS), X-Ray Diffraction (XRD) and Raman spectroscopy for crystalline structure. The surfaces wettability with nanomorphology was evaluated using a goniometer at different times (immediate, 24 h, 1 week) and with distinct post-treatments: as deposited; with a reactive plasma (Argon/Oxygen for 5 minutes) and UV-light (for 10 minutes) post-treatment; stored in air or deionized water (DI). In addition, adhesion and bone cell viability were executed after the incremental treatments, employing SEM analyzes and MTT tests. Finally, data were verified by ANOVA followed by Tukey.

Results: The surface treatment generated a topography with TiO2 nanotubes morphology (~65 nm diameter in average) and micro-roughness (~1210 nm) over the titanium. Plasma-treated surfaces resulted in the most hydrophilic samples (at all times of evaluation) and this property was maintained for a longer period when those were stored in DI water (contact angle variation of 7° to 12° angle degrees in seven days). In addition, plasma post-treatment proved to change the titanium surface crystalline phase from amorphous to anatase. On the other hand, the application of UV-light modified the surface for hydrophilic characteristics, however, the degradation of this property was more accelerated at all times of evaluation. Moreover, the surfaces stored in DI water and which had reactive plasma applied, showed greater viability and cell adhesion with statistical significance ($P < 0.05$) than the groups without plasma.

Conclusions and Clinical Implications: In conclusion, a reactive plasma system was developed and applied to improve the surface of biomedical implants. Furthermore, anodized surfaces with robust nanomorphology were created. Therewith, the surfaces modified by reactive plasma and stored in DI water suggest better hydrophilicity stability, significant viability, and interesting crystalline phase alteration on the surface, indicating future potential use on biomedical implants.

Keywords: Anodization, Surfaces, TiO2 nanotubes, Implants, Hydrophilicity