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Unraveling Soft-Tissue Integration and Surface Engineering Relation in Dental Implants

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Objectives Peri-implantitis arises due to biofilm accumulation around dental implant abutments, resulting in periodontal pocket formation, inflammation, infection and possible implant failure. Enhanced soft-tissue integration around the abutment is crucial for establishing a robust mechanical seal, thereby preventing pathogen infiltration and ensuring long-term implant success.
Methods Femtosecond laser processing is a cutting-edge technology recently being utilized for generating laser-induced periodic surface structures (LIPSS) which are surface nanotextures that have shown promise in enhancing soft-tissue growth. However, the precise connection between surface characteristics and biological response remains unclear. Given that protein adsorption is the primary biological reaction upon implantation, this study investigates the correlation between in situ protein adsorption kinetics and the surface properties of LIPSS textured titanium (LIPSS-Ti) and complemented with *in-vitro* testing using human gingival fibroblasts.
Results SEM imaging confirmed the formation of periodic LIPSS, while AFM analysis quantified their depth to be in the same range as the size of cellular filopodia. XPS analysis revealed an increase in metallic oxide presence alongside a decline in bulk metal signals. The formation of the oxide layer was validated through significant alterations in solid surface zeta potential, notably differentiating LIPSS-Ti from untextured Ti. Additionally, an increase was observed in the overall surface energy of LIPSS-Ti that can be attributed to an increased polar component. A study on protein adsorption coupled with streaming current analysis demonstrated successful protein adhesion on LIPSS-Ti and resulted in a shift of surface zeta potential towards that of the protein. This was confirmed by the affinity of the cells towards the LIPSS-Ti.
Conclusions Through the integration of comprehensive surface topography and surface chemistry characterization methodologies, this study elucidates a more profound understanding of the intricate relationship between these properties and the biological functionality exhibited by LIPSS-Ti.