Effect of nanosecond laser texturing on the topography, low-temperature degradation behaviour and biological performance of 3Y-TZP

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ABSTRACT

The surface topography of dental implants is a key parameter to achieve a strong and direct integration with the surrounding bone, however, the optimal topography that maximizes the osseointegration still remains unclear. Considering that, laser surface micro-patterning of dental-grade zirconia (3Y-TZP) was explored with the objective of providing a topography able to guide bone-cell response. A nanosecond laser was employed to fabricate micro-groove patterns on the surface of 3Y-TZP discs, yielding three different topographies according to the groove periodicity (30, 50 and 100µm). The resulting topography, surface damage and hydrothermal degradation behaviour was assessed by means of advanced characterization techniques. A cellular study was conducted to evaluate the behaviour of human mesenchymal stem cells (MSCs) on the patterned samples in terms of adhesion and cell morphology. The topographical analysis of the three patterns showed grooves of approximately 1.7µm height that exhibited surface damage in the form of pile-up, microcracks and cavities due to the melting and re-solidification associated to the nanosecond regime. The accelerated aging test revealed a slight decrease in the hydrothermal degradation resistance after the laser patterning, and interestingly, a non-homogeneous monoclinic phase distribution was observed along the laser textured surfaces. Finally, the three micropatterns enabled MSC attachment and increased cell area compared to polished zirconia. Moreover, cell morphology and alignment were influenced by the periodicity of the patterns. Among all the microtopographies, only the 50µm periodicity, which better mimics the size of the cells, significantly favoured cell elongation and alignment along the grooves, which is associated with a higher cell migration, thus paving the way to further explore this topographical pattern to tune the response of MSCs on dental zirconia.

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