Biological tissue processing with lasers for the development of new clinical applications

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The physical characterization of biological tissues irradiated by laser, mainly the study of their optical and thermal properties after irradiation, allows the development of new diagnostic or therapeutic methods in Dentistry and Medicine

Prevention of dental caries with lasers[1]

Lasers can reduce the rate of subsurface demineralization in enamel. The percentage of inhibition of dental caries varied from 30 to 97.2%, and the association with fluoride has demonstrated the best results on inhibition of caries development. Several laser wavelengths were used for this purpose. The use of TEA CO_2 laser (10.6 μm) was investigated by measuring the calcium and phosphorous content after demineralization. Although CO_2 laser irradiation does not promote any surface photomodification, it was able to significantly reduce enamel demineralization. Tetracalciumphosphate was identified as a new crystalline phase formed during Ho:YLF irradiation of enamel, detected by X-ray diffraction in a synchrotron source. Er:YAG and Er,Cr:YSGG lasers changes mainly the organic matrix (collagen) and water and little the mineral matrix (OH^- radical). The combined treatment of laser irradiation with fluoride propitiates an expressive fluoride uptake, reducing the progression of caries lesions, and this treatment is more effective than laser or fluoride alone.

Spectroscopic and thermal characterization of enamel and dentine[2]

Temperature rise during diode, Er:YAG and Er:Cr:YSGG laser irradiation of enamel and dentin was determined using thermocouple and an infrared thermographic camera. Electron spin ressonance (ESR) and Fourier transform infrared spectroscopy (FTIR), showed that after heating the tissue to temperatures between 100 and 300 ^{0}C, some water is eliminated and the hydrogen bonds, which determine collagen alpha-helix structure stabilization, are lost. After elimination, the collagen matrix is changed and electrons are probably trapped, giving rise to ESR signals and absorption bands in the ultraviolet–visible spectral range.

Caries removal and cavity preparation with lasers[3]

Enamel and dentin removal can be achieved using lasers that are strongly absorbed by these tissues. Usually the morphological pattern of Er:YAG irradiated enamel and dentin has a rough aspect with a clear exposition of the prisms and dentinal tubules. The melted surfaces covering the CO_2 laser irradiated enamel and dentin, occlude the dentinal tubules and the enamel prisms. The rough pattern after Er:YAG irradiation, which originates from the micro-explosion of water, does not occlude the dentinal tubules, whereas the surface morphology after CO_2 laser irradiation, which originated from the temperature rise above hydroxyapatite melting point, shows dentinal tubules occlusion and tissue melting. These changes increase the acid resistance and may benefit the bond strength between the tissue and composite resin used for restorations. An optical coherence tomographic (OCT) system verified the quality of restorations by measuring the distance of restorative material and normal tissue.

Keywords: caries prevention, infrared thermography, micro-FTIR, OCT.

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