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Use of femtosecond lasers for exogenous mineralization of dental enamel

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Abstract: Since dental enamel is an acellular, non-living tissue, any defect or damage is permanent due to the lack of natural remineralisation. To deal with the lack of an effective restorative procedure we propose a more permanent solution with a radically new approach that utilises femtosecond pulsed lasers and Fe^{2+}, Fe^{3+} doped calcium phosphate materials (e.g. hydroxyapatite, fluorapatite and brushite). A layer of the iron rich material is applied on to the surface of enamel. During femtosecond laser irradiation (1040 nm wavelength, 1 GHz repetition rate and 0.4 W average power), the Fe_2O_3 nanoparticles produce heat (due to photothermal effect) and trigger the sintering and densification of the calcium phosphate crystals which eventually are bonded with natural enamel. The existence of the Fe oxide nanoparticles ensures a localised temperature rise, minimising any thermal damage to natural tissue.

The hardness of the new layer is comparable with that of dental enamel (268 HK of the new layer versus 298 of enamel) and significantly higher than dentine and the commercial restorative materials. Three weeks of brushing trials prove that the wear rate of the new material is much slower than that of natural enamel. Finally after checking the cross section of the sintered samples we verified that there is restricted thermal damage to the enamel after laser irradiation.

References

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