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Hard tissue ablation with a spray-assisted mid-IR laser

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Abstract

The objective of this study was to understand the dominant mechanism(s) for dental enamel ablation with the application of water spray. A free-running Er,Cr:YSGG (yttrium, scandium, gallium, garnet) laser was used to ablate human enamel tissue at various radiant exposures. During dental ablation, distilled water was sprayed on the sample surface, and these results were compared to ablation without a spray (dry ablation). In order to identify dominant ablation mechanisms, transient acoustic waves were compared to ablation thresholds and the volume of material removed. The ablation profile and depth were measured using optical coherence tomography (OCT). Irregular surface modification, charring and peripheral cracks were associated with dry ablation, whereas craters for spray samples were relatively clean without thermal damage. In spite of a 60% higher ablation threshold for spray associated irradiations owing to water absorption, acoustic peak pressures were six times higher and ablation volume was up to a factor of 2 larger compared to dry ablation. The enhanced pressure and ablation performance of the spray-assisted process was the result of rapid water vaporization, material ejection with recoil stress, interstitial water explosion and possibly liquid-jet formation. With water cooling and abrasive/disruptive mechanical effects, the spray ablation can be a safe and efficient modality for dental treatment.

(Some figures in this article are in colour only in the electronic version)