Dental hard tissue ablation with a wavelength-tunable pulsed Cr:CdSe laser in the range of 2.76-3.00 μm

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1. Introduction

Mid-infrared Er:YAG (2.94 μm) and Er,Cr:YSGG (2.78 μm) lasers are effectively utilized for dental hard tissue treatment due to their high absorption into water and/or hydroxide ion, respectively [1-6]. We are aiming to develop a new all-solid-state laser system instead of conventional erbium lasers, and recently we developed an all-solid-state, wavelength-tunable, nanosecond pulsed Cr:CdSe laser, which enables laser oscillation in the spectral range around 2.9 μm [7].

2. Purpose

The aim of the present study was to evaluate the effects of nanosecond pulsed Cr:CdSe laser on dental hard tissues in the range of 2.76 - 3.00 μm.

3. Material and Methods

A Cr:CdSe laser was pumped with a diode-pumped Tm:YAG laser. The tuning range from 2.6 to 3.0 μm was obtained in the Cr:CdSe laser for a pumping energy of 20 mJ at 2.01 μm.

In the present study, we mainly used the wavelengths ranging from 2.76 to 3.00 μm and controlled the irradiation energy from 0.28 to 2.0 mJ (fluency: 1.6-11.2 J/cm^2/pulse, pulse duration: approximately 250 ns) and the beam diameter was approximately 150 μm on the targeting tissues. Dental hard tissues such as enamel, dentin and cementum were irradiated with the Cr:CdSe laser at 10 Hz without water irrigation.

After irradiation, morphological changes, ablation depth, and thickness of thermally affected layer of the irradiated surfaces were analyzed by stereomicroscopy, scanning electron microscopy (SEM), and light microscopy of non-decalcified histological sections.

4. Results and Discussion

Stereomicroscopy (Fig. 1) demonstrated that the Cr:CdSe laser irradiation without water cooling effectively ablated hard dental tissues with no visible thermal damage such as carbonization. The SEM examination (Fig. 2) revealed characteristic micro-irregularities without major melting and cracks of the lased dental hard tissues. The histological analysis (Fig. 3) presented the minimal thermal change of approximately 20 μm width on the irradiated dentin surfaces. The efficacy of ablation gradually increased from 3.00 μm towards 2.76 μm and wavelength of 2.76 μm revealed the highest ablation efficacy on dentin in the range of 2.76-3.00 μm.

5. Conclusions

These results demonstrated the excellent ablation effects of the nanosecond pulsed Cr:CdSe laser for dental hard tissue ablation, and clarified the remarkable wavelength dependence of its ablation effect on dentin in the range of 2.76-3.00 μm.

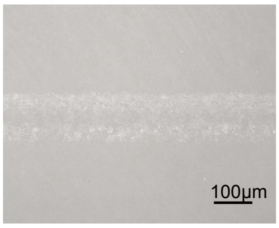

Figure. 1
Stereomicroscopy view of dentin surface after Cr:CdSe laser (2.9 μm) line irradiation with 2 mJ/pulse (fluency: 11.2 J/cm^2/pulse) and 10 Hz.

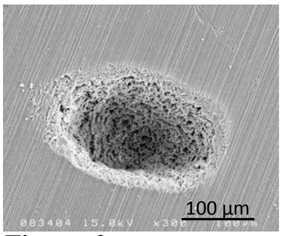

Figure. 2
SEM view of dentin surface after 10 pulses of Cr:CdSe laser (2.9 μm) spot irradaition with 2 mJ/pulse.

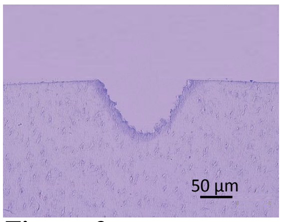

Figure. 3
Histological view of dentin surface after Cr:CdSe laser (2.9 μm) line irradiation with 2 mJ/pulse and 10 Hz.
Non-decalcified histological section.

References

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