FT- Raman Spectroscopic Studies of Nd / YAG Laser - Irradiated Human Dental Enamel

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ABSTRACT: *FT-Raman Spectra of human dental enamel, both Laser-irradiated and untreated, are reported. Spectra are compared with hydroxyapatite. It is evident that unlike the CO_2 laser, the Nd/YAG laser does not induce any chemical change in dental enamel.*

KEY WORDS: *FT-Raman Spectroscopy, Nd/YAG Laser, Human Dental Enamel, Hydroxyapatite.*

INTRODUCTION

Since 1964 when Stern and Sognnaes reported the first application of laser in dentistry [1], various types of laser have been applied to both soft and hard dental tissues. In the early studies of the effect of laser irradiation on dental enamel, a ruby laser was mainly used [2]. In recent investigations, however, the use of CO_2 laser [3], Nd/YAG laser [4] and Er/YAG laser [5] have been reported.

Several techniques including SEM [6] and XRD [7] have been used to evaluate the effect of laser irradiation on dental enamel. While it has been reported that enamel surface exposed to laser radiation has a reduced rate of demineralization compared to unirradiated enamel [8], in contrast there are some reports which oppose this view [9]. The laser induced physical or chemical changes on enamel surface are not yet fully understood and remain a subject of research interest.

We have recently reported the first Raman spectroscopic studies of CO_2 laser-irradiated human dental enamel [10] and in present work, FT -Raman spectroscopic studies of Nd/YAG laser- irradiated human dental enamel is reported.

EXPERIMENTAL

Materials

Caries and restoration - free human permanent teeth were collected, washed free of adherent blood components and stored at 4°C in distilled water. Hydroxy-

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apatite was obtained from Aldrich (Milwaukee, WI, USA) and was used without purification. Slices of teeth were used for irradiation.

Laser Treatment

Specimens were irradiated using a Nd/YAG laser (Model d laser 300, American Dental Laser, Troy, USA) operating in free-running pulsed mode. The energy was delivered using a 320 micrometre optical fibre. The laser irradiation conditions for enamel were: pulse frequency 30Hz, average power 3W and exposure time 5 seconds.

Instrumentation

FT-Raman spectra were recorded using a Perkin - Elmer FT-Raman system, Model 2000, equipped with an indium-gallium-arsenide detector. The excitation wavelength of 1064 nm was obtained from a Nd/YAG laser (I.E.Optomech, model 385).

RESULTS AND DISCUSSION

Fig.1 shows FT-Raman spectra of hydroxyapatite (a), unirradiated enamel (b) and enamel irradiated with 1064 nm radiation of a Nd/ YAG laser (c) in the wavenumber shift range 200-1800 cm^{-1}. It can be seen from Fig.1 that the spectra of both untreated and irradiated enamel are quite similar to the spectrum of hydroxyapatite (a) and this is of course quite natural, since enamel is a carbonated hydroxyapatite [11]. There are, however, 3 weak bands in the frequency range 1200-1800 cm^{-1} in the spectrum of untreated enamel which are completely absent in the Raman spectrum of irradiated enamel. These Raman bands have been assigned to collagen, the organic material of enamel[12]. Other Raman bands of all three spectra are characteristic bands of hydroxyapatite at 430, 590, 961 and 1075cm^{-1} [10].

The disappearance of collagen bands in the spectrum (c), which represents the laser - irradiated enamel, is due to a complete burning of collagen as a result of the heating effect of the laser radiation. Except for the disappearance of collagen bands, there is no difference between the spectra of untreated and laser-irradiated enamel. This means that upon irradiation with Nd/YAG laser the composition of enamel has not changed.

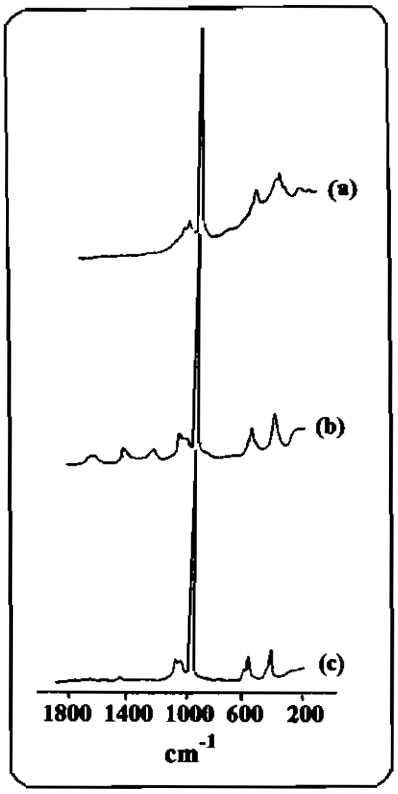

***Fig.1:** FT- Raman spectra of hydroxyapatite (a), untreated enamel (b) and enamel irradiated with 1064 nm radiation of a Nd / YAG laser (c) in the wavenumber shift range 200 - 1800 Cm^{-1}.*

In our previous studies of the effect of CO_2 laser irradiation , we observed a partial conversion of hydroxyapatite to TCP [10]. This may be explained as the influence of the wavelengths of the two lasers. The wavelength of the CO_2 laser is 10.6 μm which is equal to 943.4 cm^{-1}. This frequency is in close coincidence with the v_1 vibration of hydroxyapatite at 961 cm^{-1}. It therefore can be absorbed by enamel. The wavelength of Nd/YAG laser at 1064 nm is equal to 9398.5 cm^{-1} which is quite far - off absorption by enamel.

Our results in the present study are in exact agreement with a similar study of Nd/YAG laser- irradiated human dental enamel using SEM technique [6,13].

CONCLUSIONS

We may conclude that human dental enamel does not change its composition upon irradiation with Nd/YAG laser (at a certain power).

Laser radiation may induce certain physical changes such as melting, recrystallization , cratering and fusion, but unlike the CO_2 laser it does not induce any chemical changes in enamel.

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