ORIGINAL ARTICLES

EFFECTS OF 980 NM HIGH-POWER DIODE LASER IRRADIATION ON ENAMEL MICROHARDNESS

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REZUMAT

Scop: Evaluarea efectelor iradierii cu dioda laser GaAlAs 980 nm de putere energetică ridicată asupra microdurității smalțului și stabilirea parametrilor laser, pentru a obține o creștere eficientă a microdurității. **Material și metode:** În acest studiu au fost utilizați 36 de dinți umani mono- și pluriradiculari. Rădăcinile au fost îndepărtate, iar coroanele au fost secționate longitudinal, în două jumătăți, una reprezentând proba experimentală, iar cealaltă proba de control. Probele au fost înglobate în rășină acrilică, utilizând conformatoare cilindrice în poziție orizontală, cu suprafața plană liberă spre exterior. Suprafața plană expusă a fost iradiată cu o diodă laser 980 nm, utilizând o fibră optică cu diametrul de 220 micrometri. Au fost utilizați următorii parametrii: puterea - între 0,5 și 3 W; durata impulsului între 0,01 și 0,04 sec; timp de expunere 5 sec; timpul între expuneri 0,01 și 0,04 sec. Fiecare măsurare a microdurității a fost realizată de trei ori pentru fiecare probă. Microduritatea smalțului a fost măsurată utilizând metoda Vickers. Rezultatele au fost analizate statistic, folosind programul de analiză statistică MINITAB. **Rezultate:** Analiza statistică a demonstrat o creștere a microdurității smalțului la nivelul grupului experimental în comparație cu grupul de control ($p < 0{,}005$), când au fost utilizate intensități energetice joase. În plus, modelarea matematică a permis analiza computerizată a microdurității smalțului, când au fost cunoscuți parametrii de lucru ai sistemului. **Concluzii:** Dioda laser de putere energetică ridicată are drept efect creșterea microdurității smalțului, prevenind astfel incidența apariției cariei dentare.

Cuvinte cheie: microduritatea smalțului, diodă laser, carii dentare

ABSTRACT

Purpose: To evaluate the effects of high-power diode laser irradiation on enamel microhardness and to establish the best laser parameter settings in order to achieve an effective increase of microhardness. **Materials and methods:** 36 human single and multi-rooted teeth were used in this study. The roots were removed and the crowns were sectioned longitudinally in two halves, one representing the experimental sample and one the control sample. The samples were embedded in acrylic resin using cylindrical conformators in horizontal position leaving the flat surface outside. The flat surface of the experimental samples was irradiated using a 980 nm diode laser with an optical fiber diameter of 220 micrometers. The following parameters were used: power, ranging from 0.5 to 3 W; pulse width, ranging from 0.01 to 0.04 sec; exposure time of 5 seconds, resting time, ranging from 0.01 to 0.04 sec. Each microhardness measurement was performed three times on each sample. The enamel microhardness was measured using the Vickers method. The results were analyzed statistically using the MINITAB statistical software. **Results:** The statistical analysis demonstrated an increase of enamel microhardness in the experimental group, compared with the control group ($p < 0.005$) when using low energy densities. Moreover, the mathematical modeling allowed enamel microhardness computation when the parameters of the running system were known. **Conclusion:** The high-power diode laser is effective for increasing the enamel microhardness, preventing the occurrence of dental caries.

Key Words: enamel microhardness, diode laser, dental caries

INTRODUCTION

Although declining, dental caries are still the most prevalent disease during childhood and adolescence. Among artificial methods for the protection of dental structures, lasers have been tested in order to improve dental enamel properties under acidic conditions. Enamel microhardness seems to be related to enamel mineral content and plays a role in enamel demineralization inhibition.[1-4]

The aim of our study was to evaluate the effects of high-power 980 nm diode laser irradiation on enamel microhardness and to establish the best laser parameter settings in order to achieve an effective increase of microhardness.

MATERIALS AND METHODS

36 single and multi-rooted teeth were used in this study. The roots were removed and the crowns were sectioned longitudinally in two halves with a diamond

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disc and under water cooling, one representing the experimental sample and one the control sample. The samples were embedded in acrylic resin using cylindrical conformators in horizontal position leaving the flat surface outside. The samples were ground wet to achieve a flat enamel surface using 600, 1000, 1200 grit silicon carbide paper and then polished with 0.2 and 0.05 microns alumina slurry. (Fig. 1)

Figure 1. The sample preparation for measuring the enamel microhardness.

The samples were kept in distilled water at room temperature before they were tested the same day. The flat surface of the experimental samples was irradiated using a 980 nm diode laser with an optical fiber diameter of 220 micrometers. (Figs. 2,3)

Figure 2. The laser device used.

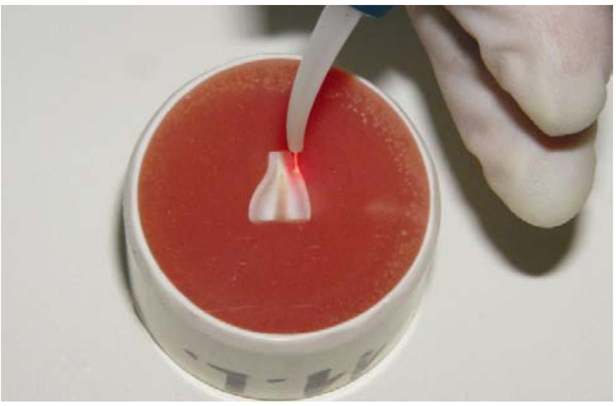

Figure 3. The sample irradiation procedure.

The following parameters were used: power, ranging from 0.5 to 3 W; pulse width, ranging from 0.01 to 0.04 sec; resting time, ranging from 0.01 to 0.04 sec; exposure time of 5 seconds. Each microhardness testing was replied three times on each sample. (Fig. 4) The enamel microhardness was measured using the Vickers method. (Fig. 5) The results were analyzed statistically using the MINITAB statistical software. (Table 1)

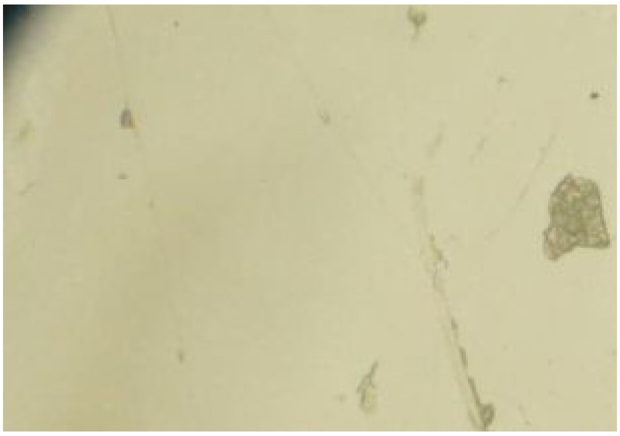

Figure 4. Microscopic view of the sample surface prepared for enamel microhardness testing (200X).

Figure 5. The devices used for measuring the enamel microhardness.

One-way ANOVA: Group I - Diode laser, Group II - Control

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Analysis of Variance
Source     DF        SS        MS        F       P
Factor      1     70563     70563    11.36   0.001
Error      70    434962      6214
Total      71    505524
                                    Individual 95% CIs For Mean
                                    Based on Pooled StDev
Level       N      Mean     StDev   ---------+---------+---------+------
Group I    36    443.03     72.21                        (-------*------)
Group II   36    380.42     84.93   (-------*------)
                                    ---------+---------+---------+------
Pooled StDev =    78.83                    385       420       455
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Figure 6. The results of the one-way ANOVA statistical analysis ($p < 0.005$).

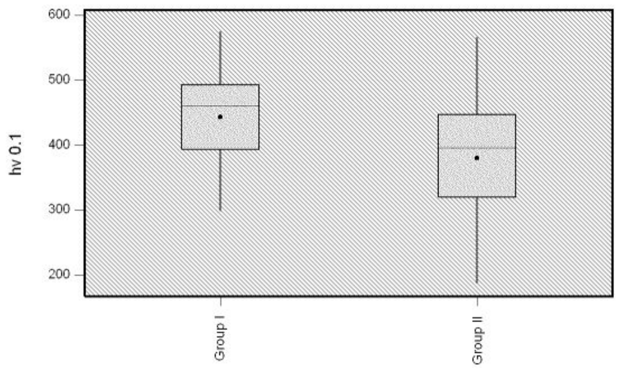

Figure 7. Boxplot representation of the results of the statistical analysis (means are represented by solid circles).

Table 1. The results of the enamel microhardness measurements (hv 0.1).

Tooth No.	Diode Laser Group	Control Group
1	498	237
2	476	302
3	493	309
4	487	376
5	499	417
6	486	450
7	572	450
8	401	473
9	508	566
10	377	263
11	493	372
12	473	358
13	465	478
14	498	390
15	379	397
16	327	433
17	298	383
18	326	394
19	392	413
20	457	425
21	467	363
22	487	503
23	523	437
24	437	401
25	575	240
26	428	186
27	332	219
28	399	454
29	551	454
30	451	459
31	312	342
32	469	411
33	398	319
34	401	298
35	447	401
36	367	322

RESULTS

The statistical analysis demonstrated a microhardness increase of enamel microhardness compared with the control group ($p < 0.005$). (Figs. 6,7) However, in some cases, the results indicated a reduction of the enamel microhardness of the experimental samples as compared to the controls.

DISCUSSIONS

When treating the enamel of human extracted teeth with laser, important morphological alterations can occur.[2,4] These alterations have been related to some changes of a different nature that have been defined by some authors as change in the mineral composition, decrease in the organic matter, or structural reorganization of the hydroxyapatite crystals. The effect generated can usually be considered as a surface microfusion of the enamel, and it depends on the total energy absorbed. On the other hand, the conditions of application must allow maximum energy absorption in minimal time, in order to prevent any thermal damage to the soft tissues. Previous studies have demonstrated the ability of CO_2 and Nd:YAG lasers to increase enamel microhardness.[3,5-7] So far, no published data are available concerning the effect of 980nm high-power diode laser on enamel microhardness. Based on the present study's results, further research is required on teeth with approximately the same degree of mineralization.

CONCLUSIONS

The results of the present in vitro study emphasize the effectiveness of high-power diode laser in increasing enamel microhardness, thus reducing the occurrence of dental caries. Moreover, the results suggest that the best micorhardness is achieved when using low energy densities.

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