Comparative Evaluation of Dentine Surface Changes Following Nd:YAG Laser Irradiation by SEM

R. Birang*, J. yaghini**

ABSTRACT

Introduction: Dentine hypersensitivity is a common clinical problem in dental practices. So several methods such as, Nd: YAG laser have been used to treat this problem. Previous studies reported that Nd:YAG laser irradiation on root surface makes some thermal changes, like dentine melting and some other side effects which are related to power of laser irradiation. The aim of our study was to compare two different settings of Nd: YAG laser to evaluate their efficacy in occluding dentinal tubules and their side effects by means of SEM.

Methods: 15 newly extracted mandibular molars were selected and the specimens with certain dimensions from buccal surface and below CEJ were prepared. Specimens were divided in 3 groups: group 1 (control), were not irradiated by laser; group 2, irradiated by Nd:YAG laser (0.5w, 10Hz, 60Sec, 2 times); and Group 3, irradiated by Nd:YAG laser (1w, 10Hz, 60Sec, 2 times). After preparation and gold coating of specimens, the photomicrographs were seen by SEM in magnification of 100 and 1500. Finally, the number and diameter of dental tubules, crater and microcraks were determined in each group. After that, the data was analyzed using ANOVA test.

Results: Results of this study showed that diameter of dentinal tubules were reduced in Nd: YAG irradiated groups, compared with control group. Also there were no significant differences in the mean number of open dentinal tubules between Nd:YAG (0.5 watt) and control group. On the contrary, there were significant differences between Nd:YAG (1 watt) and the other groups . Meanwhile, no group showed micro cracks or craters.

Conclusion: The results of this study show that Nd:YAG laser irradiation can cause thermal effects such as decrease in dentinal tubules diameter or their occlusion. Also 1 watt power Nd:YAG laser is more effective than 0.5 watt power in tubules occlusion which is a necessary factor in dentine desensitization.

Key words: Dentine hypersensitivity, Nd:YAG laser, Dentinal tubules, Scanning electron microscope (SEM).

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Introduction

Dentine hypersensitivity (DH) is a common clinical problem in dental practices [1]. DH is characterized by short, sharp pain arising from exposed dentine in response to a stimuli, typically thermal, evaporative, tactile, osmotic, or chemical which cannot be ascribed to any other form of dental defect or pathology [2]. This problem can be resulted from non appropriate brushing, gingival recession, erosion, attrition, and abfractive lesions [3]. The incidence of DH is so high that some dentists mention it as an ordinary occurrence and discourage the patients for treatment. But it is necessary to notice that DH can cause sharp and severe pain, patient

*Assistant Professor, Faculty of Dentistry, Isfahan University of Medical Sciences, Isfahan ,Iran.
**Periodontist
Corresponding author: Dr Reza birang , Faculty of Dentistry ,Isfahan University of Medical sciences ,Isfahan ,Iran.

discomfort, and decrease the level of cooperation in regard to oral hygiene. Therefore, treatment of DH following periodontal treatment is necessary [4-5].

In 1935, Grossman suggested some criteria to treat this problem which is still logical to be considered [6]. Several methods have been used but because of absence of those criteria, most of them didn't result in a good success. So, in the middle of 1980, use of laser was proposed [7]. Till now, many kinds of lasers like He – Ne, Ga – Al – As, Co2, Nd: YAG, and recently Er: YAG have been used but use of Nd:YAG laser has been more successful than the others [8]. First time, Matsoumoto in 1985, used Nd: YAG to treat patients suffering from DH. Ever since, many investigators have done some investigations in this field and all of them have reported the success in treatment [9]. These studies have shown that Nd: YAG laser has no harmful effect on dental pulp within the limit of desensitization parameters [10].

Several studies have shown that the use of Nd: YAG laser irradiation on root surface makes some thermal changes, like melting the cementum and root dentine which may partially or totally obliterate dentinal tubules. In addition, side effects such as carbonization, craters, and micro cracks can ensue [11-12].

Israel (1997), Lan (1999, 2004), Gaspric and Skaleric (2001), and Magalhaes (2004) have reported that laser irradiation on dentine surface can occlude dentinal tubules. However, some of them have emphasized that the severity and kind of root surface changes are related to power of laser [13-17].

The aim of our study was to compare two different settings of Nd: YAG laser to evaluate their efficacy in occluding dentinal tubules and their probable side effects by means of SEM.

Methods and Materials

In this study, 15 newly extracted mandibular molar teeth with a large mesio distal area on root surfaces were selected. Three tooth bulks with the dimensions of 2×2×1 mm were prepared from below the CEJ of buccal surface of each tooth. In order to clean off the smear layer from the surfaces, the pieces were embedded in 17% EDTA (pH = 7.8) for five minutes and then in %5.25 sodium hypochlorite for 5 minutes. Finally, all the samples were washed with 5 ml of distilled water [18]. A simple randomized method with blind selecting of the samples was used to divide these bulks to three different groups. First group leaved as control without any laser treatment. For irradiating the second and third groups, the Nd: YAG laser was used with the power of 0.5W (50 mJ, 10 Hz, 60 Sec, 2 times) and 1 W (100 mJ, 10 Hz, 60 Sec, 2 times), respectively. The diameter of output beam was about 300 μm. The distance between laser fiber or tip and tooth root surface was 2 mm in all the experiments. A fidelis plus laser system (Fotona, Ljubljana, Slovenia) was used. For this purpose, we used a piece of orthodontic wire jointed to the end of Nd: YAG optic fiber and overlapping sweeping motion was used in the horizontal direction.

After treating, all samples were transferred to materials science school of Isfahan industrial university for SEM imaging (XL-30, Philips, Netherlands).In order to preparation of samples for SEM analyzing, the following stages were done: fixation, post fixation, washing, dehydration, deceication ,and finally gold coating [18] .Then the photomicrographs were used with magnifications of 100 and 1500for micro-cracks, and dentinal tubules changes and crater form investigations, respectively.

For evaluating the diameter of dentinal tubules, a digitalized caliber was used. All the tubule orifices in any field were measured with this tool and the average of diameters was reported. Using fixed scale, the real sizes were extracted in all the images and used for statistical analysis.

Counting of the open tubules with the aim of evaluating the closure of them by laser irradiation was done. Also, the presence of crater in magnification of 1500 was reported as a possible side effect. Micro cracks were counted and reported, if seen, with the magnification of 100 times in any field that showed such a feature. After that, the data was analyzed with analysis of variance (ANOVA) test, using SPSS software.

Results

According to the findings, the data showed that the average diameter of dentinal tubules in group1 (control) was $5.1 \pm 0.6\,\mu m$, in group 2 (0.5 Watt) was $3.4 \pm 0.7\,\mu m$, and in group 3 (1Watt) was $2 \pm 0.4\,\mu m$. The difference between groups 1 and 3 (P=0.000), groups 2 and 3 (P=0.000), and groups 1 and 2 (P=0.000) were significant (tables 1, 2).

Furthermore, the average of open dentinal tubules numbers was 51 ± 9 in group 1, 45 ± 8 in group 2, and 17 ± 6 in group 3. There was no significant difference between groups 1 and 2 (P=0.719), but the differences between groups 1 and 3 and groups 2 and 3 were significant (P=0.000) (tables 3, 4). Meanwhile, no group showed micro cracks, craters, or Carbonization.

Table 1: Indices of dentinal tubules diameters in different groups (n=15).

	Dentinal Tubules Diameters			
Group	Min(µm)	Max(µm)	Differences Range	Mean ± SD
Control	4.3	6.2	1.9	5.1 ± 0.6
Nd:YAG 0.5w	2.4	4.2	2	3.4 ± 0.7
Nd:YAG 1w	1.3	2.4	1.1	2 ± 0.4

Table 2: Comparison between diameters of open dentinal tubules in different groups (n=15).

Comparative Groups	P-value	Significance
Control/ Nd:YAG 0.5 W	0.000	Yes
Control/ Nd:YAG 1 W	0.000	Yes
Nd:YAG 0.5 W/ Nd:YAG 1 W	0.000	Yes

Table 3: Number of open dentinal tubules in different groups (n=15).

	Number of Open Tubules			
Group	Minimum	Maximum	Differences Range	Mean± SD
Control	37	62	25	51 ± 9
Nd:YAG 0.5 W	35	57	22	45 ± 8
Nd:YAG 1 W	12	28	16	17 ± 6

Table 4: Comparison between number of open dentinal tubules in different groups (n=15).

Comparative Groups	P-value	Significance
Control/ Nd:YAG 0.5 W	0.719	No
Control/ Nd:YAG 1 W	0.000	Yes
Nd:YAG 0.5 W / Nd:YAG 1W	0.000	Yes

Discussion

In this study, the effects of Nd:YAG laser irradiation were evaluated on some structural features of dentine, like changing in number and diameter of dentinal tubules and some side effects like craters, micro cracks ,and the relation between these changes and suggested parameters. As shown in the tables 1 and 2, changes in diameter of dentinal tubules in Nd:YAG laser irradiated groups, compared to control group, was significant (P<0.0001).

Also, according to the data shown in the tables 3 and 4, number of open dentinal tubules in Nd:YAG laser irradiated group (1 watt) was significantly lower (P<0.0001), compared to control and Nd:YAG laser irradiated groups (0.5watt). If we consider the criteria for dentinal tubules sealing (which is an important determinant in desensitization of dentine) as changes in tubules diameters and number of occluded dentinal tubules, therefore the results of this study is in accordance with results of studies of Lan in 1999 and 2004 and Magalheas in 2004 [14, 16, 17]. However, in comparison with these studies, we mention minute differences in irradiation parameters. Also, previous studies have been qualitative, but our study is a quantitative one.

It seems that Nd:YAG laser changes dentinal surface features by melting the dentine and its recrystalization, so that most of samples irradiated with Nd:YAG laser (1watt) don't have a regular dentinal tubules structure. However, in samples irradiated with Nd:YAG laser (0/5 watt), thermal effects are considerably less and most of them have regular dentinal structures. According to the results of this study, Nd:YAG laser (0.5watt) caused decrease in dentinal tubules diameter, but Nd:YAG laser (1watt) mostly causes tubules occlusion and their disappearance (figures 1-3).

We can suppose that Nd:YAG laser (1watt) can cause so much thermal effects that causes dentine melting and tubules occlusion with deposits of melted minerals. This occlusion of dentinal tubules, according to previous studies, would directly result in a decrease of dentin hypersensitivity [19-21].

However, in use of Nd:YAG laser (0.5watt), irradiation thermal changes are considerably less and so minimal dentine melting happens in tubules orifices and the relative decrease in their diameters is minimal, too. Studies of Gelskey et al (1993), Gutknecht et al (1997), and Lan et al (1999, 2004) suggested using minimal Nd:YAG laser power for dentinal desensitization [14, 16, 22, 23]. However, the results of this study show that low power Nd:YAG laser doesn't cause complete occlusion of dentinal tubules. In this case percentage of treatment effectiveness is low and / or inconsistent [3].

Furthermore, in a study which was performed by Gaspric and skaleric in 2001, craters had been mentioned as a possible side effect [15] but in our study we didn’t find any craters following Nd:YAG laser irradiation. This can be due to appropriate use of Nd:YAG laser parameters in this study. The laser also was manipulated in pulse mode and in a sweeping motion with no contact of the surface to minimize excessive thermal accumulation in any particular site. One of the other side effects encountered in samples of Gaspric and Skaleric study [15] was micro cracks, following Nd:YAG laser irradiation.

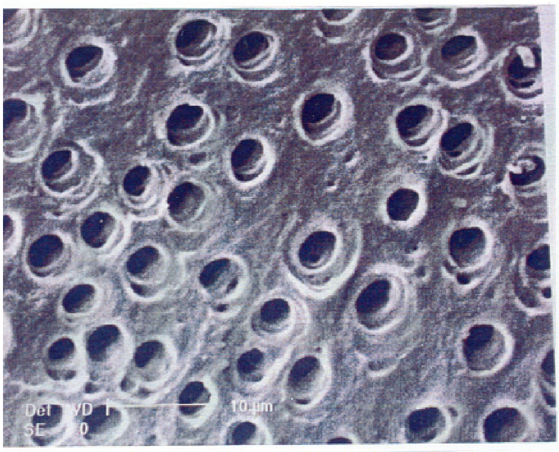

Figure 1: Control specimen (not irradiated).

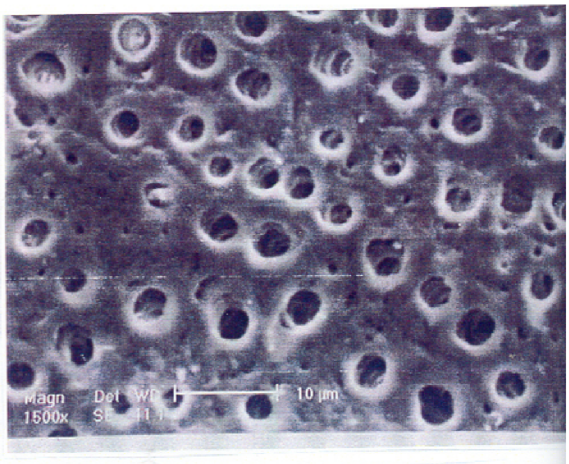

Figure 2. Nd:YAG laser irradiated specimen (0.5watt)

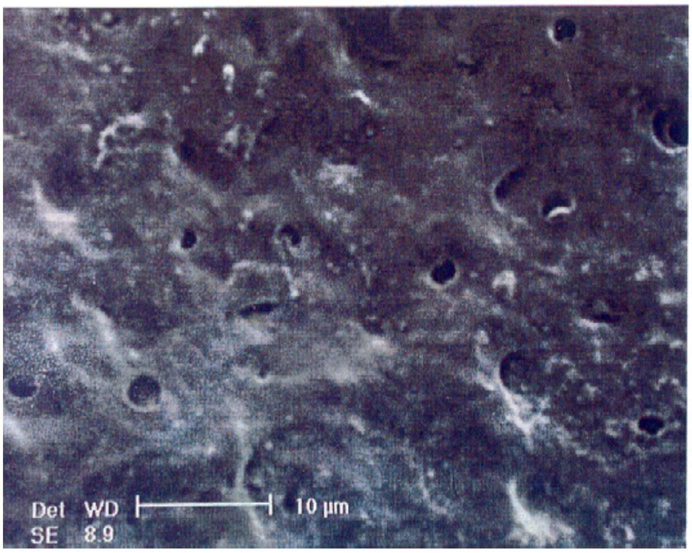

Figure 3. Nd:YAG laser irradiated specimen (1 watt)

This is also in contrast with our study in which we didn't find any micro cracks.

The results of this study show that Nd:YAG laser irradiation can cause thermal effects such as decrease in dentinal tubules diameter or their occlusion. Also 1 watt power Nd:YAG laser is more effective than 0.5 watt power in tubules occlusion which is a necessary factor in dentine desensitization.

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