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Effects of Nd:YAG and Er:YAG Lasers on the Sealing of Root Canal Fillings

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ABSTRACT

Objective: **The ability of the laser irradiation to promote the cleaning and disinfection of the radicular canal system has become this type of treatment in a viable and real alternative in endodontics. The purpose of this study was to evaluate the apical marginal sealing of root canal fillings after the irradiation with the laser of Nd:YAG or of Er:YAG.** ***Materials and Methods:*** **Forty-two human, extracted single-rooted teeth had their crowns sectioned and the root canals prepared with a no. 70 K-file. Then, they were dried and divided into three groups according to canal wall treatment: group 1: the canals were filled with EDTA for 3 min, followed by irrigation with 1% sodium hypochlorite solution; group 2: the canal walls were irradiated with Nd:YAG laser; and group 3: the canal walls were irradiated with Er:YAG laser. Afterwards, the root canals were obturated by the lateral condensation technique. The roots were externally waterproof, except in the apical foramen and immerged in 2% methylene blue aqueous solution during 48 hours.** ***Results:*** **The results showed that the largest infiltrations happened in the group 3–Er:YAG (7.3 mm), proceeded by the group 1–EDTA (1.6 mm) and by the group 2–Nd:YAG (0.6 mm). The group Er:YAG differed statistically of the others ($p < 0.05$).** ***Conclusion:*** **It was concluded that the Er:YAG laser intracanal irradiation previously to the root canal filling must be used with caution until future research is define the best parameters for it's use.**

INTRODUCTION

BECAUSE OF ITS INCREASED USE IN ENDODONTICS, the laser has been subjected to many investigations. The effects of laser application on bacterial reduction have been also explored specially because it is considered a method of easy application since it eliminates the waiting period of intracanal medication prior to root canal obturation. In 1990, Hardee et al.[1] proved the bactericidal action of the Nd:YAG laser in root canals previously contaminated by *Bacillus estearothermophilus* and, in 1991, White et al.[2] reported bacterial reduction with the use of laser Nd:YAG on the dentin contaminated by *B. subtilis* and *Escherichia coli.*

However, the use of laser can cause morphological changes on the dentin. In 1985, Zakariasen et al.[3] reported fusion and recrystallization of the dentin when the laser Nd:YAG was used, whilst Miserendino et al.[4] in 1995 reported sealing of dentine tubules or even charred dentin using laser with different energy.[5] Still using the Nd:YAG laser Goodis et al.,[6] Goodis et al.,[7] and Harashima et al.,[8] reported the removal of the smear layer and morphological changes such as fusion and recrystallization of the dentin. Therefore, morphological changes, due to the use of laser, may influence the marginal sealing of the root canal obturations. The purpose of this study is to evaluate the marginal sealing of root canal obturations previously treated with laser.

MATERIALS AND METHODS

Specimen preparation

Forty-two extracted human teeth were stored in closed containers with 10% formalin solution.* Each root was selected ac-

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cording to its external and internal anatomy, and presented a single straight canal and round root apex. They were sectioned at the cervical region, with a standardized length of about 15 mm. The root canal was explored in all its extension using a K-file #10. The root apex was cut at 0.5 mm using a carborundum disk mounted on high speed.

The 42 roots received biomechanical treatment in sequence up to Kerr instrument size 70 and escalating of the preparation was performed 1mm less than the working length with a K-file no. 80. During the biomechanical preparation, all canals were abundantly irrigated with a 1% sodium hypochlorite solution after each instrument was changed, with a total of 50 mL for each canal prepared. The roots were stored in sterile containers with physiologic saline solution. The specimen were divided into three groups, with 14 roots each, according to the dentin walls treatment:

a) Group 1: root canals were dried and filled with EDTA solution, which was stirred inside the canal with a K-file no. 15 for 3 min. To neutralize the EDTA, the canals were irrigated with 10 mL of physiological saline solution;
b) Group 2: root canals were dried and irradiated with Nd:YAG laser on all its extension. The specimens were stored in physiological saline solution;
c) Group 3: root canals were dried and irradiated with Er:YAG laser on all its extension. The specimens were stored in physiological saline solution.

Laser irradiation

The Nd:YAG laser used in this study was the model d-laser 300-American Dental Technologies, high intensity pulsed laser. The energy used for the irradiation was 100 mJ, pulse frequency was set at 15 Hz with a maximum output of 1.5 W. The laser beam was conducted by optical fiber with 0.32-μm diameter and by contact mode.

The optical fiber was introduced into the root canal and the irradiation started from the apex following all root canal extension with circular movements for 5–7 sec. This procedure was repeated four times, total exposure of 20 sec.

The Er:YAG laser used in this study was the Kavo Key 2 laser, Er:YAG laser, pulsed, high intensity. The energy used for the irradiation was 120 mJ, frequency of 10 Hz and, power 1.2 W. The laser beam was conducted by optical fiber, 0.375-μm diameter (with three rings), by contact mode.

The optical fiber was introduced into the total length of the root canal, and the dentin wall was irradiated from apex to cervical in all its extension, with circular movement for 5 to 7 sec with a speed of 2 mm/sec.[9] This procedure was repeated four times, total exposure of 20 sec.

Evaluation of the apex marginal sealing

After the treatment of the root canal walls, the external root surface of the 42 roots was sealed with two layers of red nail polish, except on the cervical opening and apex foramen.

The roots were once more irrigated with physiologic saline solution and then dried. A main gutta-percha cone was selected (cone no. 70) to perform the root canal filling in all the root canal extension up to the apex limit. When the cone exceeded the root canal length, it was cut with a scalpel blade no. 15 and its locking was tested again. The cement used for the obturation was Top Seal (Dentisply Maillefer, Maillefer Instruments, Ballaingues, Switzerland), which was used according to the manufacturer instructions. The obturation was performed following a lateral condensation technique with gutta-percha cones.

X-rays were taken, the mesio-distal way, to verify the quality of the obturations and then the excessive obturation material in the cervical region was cut with a hot hand condenser. The roots were sealed again with sticky wax, except on the apical region, leaving only the obturation material of the root canal exposed. Two roots in each group were separated for control: positive internal control, which remained with the access opening and apical foramen without seal and the root was obturated only with gutta-percha cone, without endodontic cement; and negative internal control, that had the root canal obturation performed in the same way as the experimental group, and had the external radicular surface completely sealed with sticky wax. The teeth were immersed in 2% methylene blue dye solution (Terapeutica Pharmacy, São José dos Campos, SP, Brazil) at a temperature of 37 ± 1°C with 100% relative humidity for 48 h. The immersion was performed in a vacuum environment of 20 mm Hg created by a vacuum pump (Dia-Pump Fanem-Ltda) connected to a dissector.

The roots were rinsed in tap water for about 24 h, dried, and then had the external sealing layers removed, after that they were fractured in the vestibulo-lingual direction, following the root canal way to the foramen, emphasizing the apical one third of the obturation of the root canal. Two examiners performed the evaluation of the dye infiltration by the interface of the obturation material and the vestibular and lingual wall of the root canal using a stereomicroscope with ocular micrometer.

The highest infiltrations registered for each specimen and the data obtained were submitted to statistical analysis using the one-way analysis of variance test (ANOVA).

RESULTS

Table 1 shows the mean infiltration observed for each group. It can be observed in Figure 1 that the dye penetration after the use of Er:YAG laser presented mean scores and interquartil range greater than those observed with the use of EDTA and Nd:YAG laser.

Figure 2 shows the standard deviation. The higher dispersion degree of the Er:YAG laser was noticed when compared to the other groups.

Figure 3 shows the results of the homogeneity of variance test and from this data the one-way ANOVA test was performed, followed by the Tukey test (5%), where a statistic significance between groups 1 and 3 (EDTA versus Er:YAG) and groups 2 and 3 (Nd:YAG versus Er:YAG) was reported. There was no statistical significance between groups 2 and 1 (EDTA versus Nd:YAG).

TABLE 1. MEAN SCORES FOR INFILTRATION (MM) FOR THE GROUPS

Groups	*Group 1 (EDTA)*	*Group 2 (Nd:YAG)*	*Group 3 (Er:YAG)*
Mean scores (mm)		1.6 mm	0.6 mm	7.3 mm

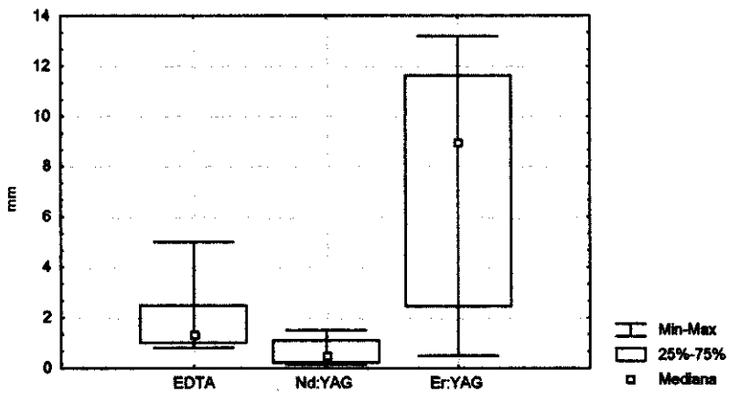

FIG. 1. Box plot referring to the data of the dye penetration according to root canal walls treatment.

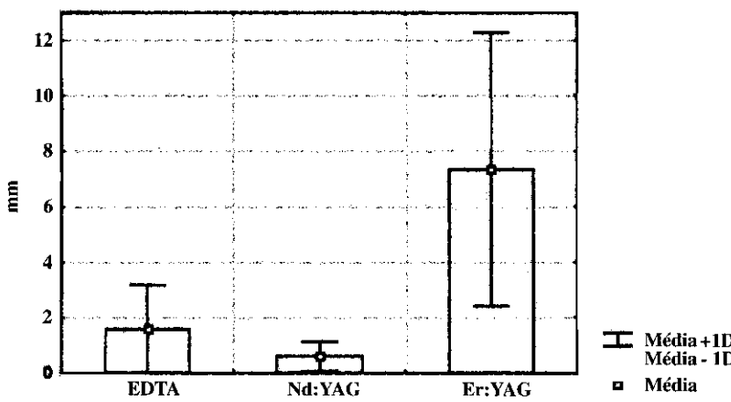

FIG. 2. Graphical illustration of representative columns of the mean and standard deviation, according to experimental groups.

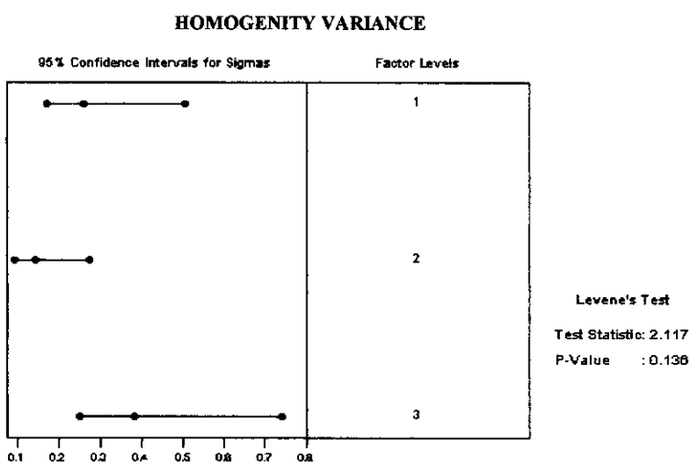

FIG. 3. Results of homogeneity of variance test (Levene test) to the transformed data, according to logarithmically function.

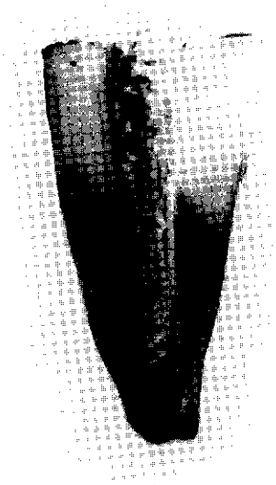

FIG. 4. Representative Illustration of the linear infiltration happened in one of the specimens of the group 1 (EDTA).

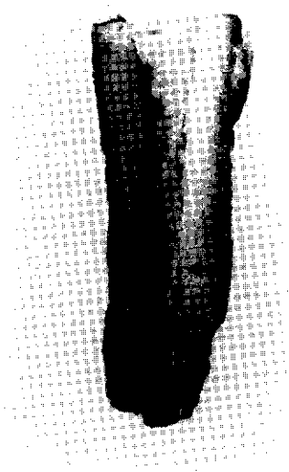

FIG. 6. Representative Illustration of the linear infiltration happened in one of the specimens of the group 3 (Er:YAG).

DISCUSSION

With the increased use of laser in dentistry, much research reported its bacterial reduction ability, because of its effectiveness in eliminating microorganisms in the waiting period of intracanal medication prior to root canal obturation. Morphological changes in the root canal walls can, however, influence the success of the treatment since it can interfere with the adaptation of the obturation.

The results of this research shows that group 3 (Er:YAG) presented higher mean and statistically significant infiltration levels, when compared to the levels of the other groups (Table 1 and Fig. 3).

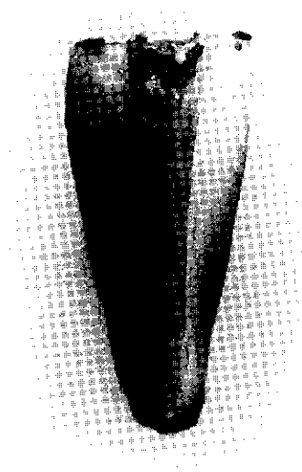

FIG. 5. Representative Illustration of the linear infiltration happened in one of the specimens of the group 2 (Nd:YAG).

It was expected that a lower infiltration degree would be observed with the use of Er:YAG laser, since it promotes exposition of the dentin tubules, removal of the smear layer, with increase of dentin permeability.[10,11] These observations would justify a better marginal sealing of the root canal obturations after the use of this laser.

Although the Er:YAG laser does not promote the melting of the dentin neither the closure of the dentinal tubules, it causes a reduction on the dentin layer due to the ablation process, forming craters and consequently a rough surface with great irregularity as described by Dostálová et al.,[12] who observed a decrease of the dentin layer in cavity preparation with the use of Er:YAG laser. Besides that, during the ablation process, the dentin is not vaporized, and can be dislodged to other areas, including to the apical region, making more difficult the adherence of the obturation material to the root canals walls.

The lowest infiltration degrees were present in the specimens of the Nd:YAG laser group, those infiltrations were lower than the ones observed in the group where the smear layer was removed by EDTA. Even with the obliteration of some dentin tubules, it is probable that the uniform roughness surface left on the dentin walls could have favored the adhesion of the cement with, consequently better marginal sealing.

As far as the use of EDTA is concerned, the results of the present study showed that this procedure is desirable since it allows a good sealing of the obturations (Table 1). This result agrees with some works such as those of Cergneux et al.,[13] in 1987, and Saunders and Saunders,[14] in 1992, who concluded that the removal of the smear layer could perform a better marginal sealing of the root canal obturation.

It is observed that there are no other studies related to the subject studied in this present research, and other *in vitro* studies are necessary to elucidate the data obtained and the clinical use of laser prior to root canal obturations.

CONCLUSION

Considering the proposed methodology, its limitations and results obtained, it can be concluded that:

a) According to previous treatment of the dentin, the smaller dye penetration through the obturation was observed in group 2 (Nd:YAG laser); Fig. 5) followed by group 1 (EDTA; Fig. 4) and then by group 3 (Er:YAG laser; Fig. 6)
b) Group 3 (Er:YAG laser) presented mean dye penetration statistically higher than groups 1 (EDTA) and 2 (Nd:YAG laser)
c) Groups 1 (EDTA) and 2 (Nd:YAG laser) were not statistically different between themselves
d) The E r:YAG laser must be used with caution in endodontic therapies until other researches can define the suitable parameters

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REFERENCES

1. Hardee, M., Miserendino, L., and Kos, W. (1990). Evaluation of the antibacterial effects of intracanal Nd:YAG laser irradiation. J. Endod. 16, 194.
2. White, J.M., Goodis, H.E., and Cohen, J.N. (1991). Bacterial reduction of contamined dentin by Nd:YAG laser. J. Dent. Res. 70, 412.
3. Zakariasen, K.L., Dederich, D.N., and Tulip, J. (1985). Nd:YAG Laser fusion of dentin plugs in root canals. J. Dent. Res. 64, 239.
4. Miserendino, L.J., Levy, G.C., and Rizoiu, I.M. (1995). Effects of Nd:YAG laser on permeability of root canal wall dentin. J. Endod. 21, 83–87.
5. Barbakow, F., Lutz, F., and Havraneck, L. (1998). SEM and microscope evaluation of Nd:YAG lased root canal walls. J. Endod. 24, 276.
6. Goodis, H.E., White, J.M., Moskowitz, E., et al. (1992). Root canal system preparation: conventional versus laser methods *in vitro*. J. Dent. Res. 71, 162.
7. Goodis, H.E., White, J.M., Marshall, S.J., et al. (1993). Scanning electron microscopic examination of intracanal wall dentin: hand versus laser treatment. Scanning Microsc. 7, 979–987.
8. Harashima, T., Takeda, F.H., Kimura, Y., et al. (1997). Effect of Nd:YAG laser irradiation for removal of intracanal debris and smear layer in extracted human teeth. J. Clin. Laser Med. Surg. 15, 131–135.
9. Gutknecht, N., Kaiser, F., Hassan, A., et al. (1996). Long-term clinical evaluation of endodontically treated teeth by Nd:YAG lasers. J. Clin. Laser Med. Surg. 14, 7–11.
10. Gouw-Soares, S.C., Lage-Marques, J.L., and Eduardo, C.P. (1996). Apicectomy by Er:YAG laser: permeability and morphological study of dentine cut surface. Int. Laser Cong., Sept, 365–369.
11. Cussioli, A.L., Brugnera, J.A., Zanin, F., et al. (1999). Avaliação da permeabilidade dentinária radicular, após o uso do laser de Er:YAG. Presented at Reunião Anual da Sociedade Brasileira de Pesquisa Odontologica, São Paulo, Brazil.
12. Dostálová, T., Jelínková, H., Krejsa, O., et al. (1997). Dentin and pulp response to Erbium:YAG laser ablation: a preliminary evaluation of human teeth. J. Clin. Laser Med. Surg. 15, 117–121.
13. Cergneux, M., Ciucchi, J.M., Dietschi, J.M., et al. (1987). The influence of smear layer on the sealing ability of canal obturation. Int. Endod. J. 20, 228–232.
14. Saunders, W.P., and Saunders, E.M. (1992). The influence of smear layer upon the coronal leakage of gutta-percha root fillings and glass ionomer sealer. Int. Endod. J. 25, 245–249.

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