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Scanning Electron Microscopy (SEM) and Optical Microscopy: Effects of Er:YAG and Nd:YAG Lasers on Apical Seals after Apicoectomy and Retrofill

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ABSTRACT

Objective: **This study evaluated the dentinal and marginal permeability of the cut surface after apicoectomy, treatment and retrocavity preparation with Er:YAG and Nd:YAG lasers. Furthermore, scanning electron microscopy (SEM) analysed the morphological alteration of dentin caused by laser irradiation through an optical fiber.** ***Background Data:*** **Numerous studies have shown the beneficial effects of laser treatment upon sealing dental apex, avoiding the changes of organic fluids, microorganisms and their by-products between the root canal system and periapex.** ***Materials and Methods:*** **Twenty-four extracted and endodontically treated teeth were divided into three groups: GI, apices were resected with Er:YAG laser (350 mJ; 4 Hz) treatment of cut dentinal surface and retrocavity were lased with this same laser (120 mJ; 4 Hz; bur 2051) using the optical fiber 50/10; GII, apicoectomy was performed similar to GI, however the cut dentinal surface was treated with Nd:YAG laser through optical fiber, as well as the retrocavity preparation (100 mJ; 15 Hz; 1.5 W); and GIII (control group), high speed burs were used.** ***Results:*** **Analysis of methylene blue dye penetration into dentin demonstrated that the specimens of the groups irradiated with laser showed to have lower infiltration indices than the control group. These results were compatible with structural and morphological injuries, evidenced by SEM.** ***Conclusion:*** **Under the conditions of the present study, apicoectomy using Er:YAG laser, followed by dentinal surface irradiation and retrocavity preparation with Nd:YAG laser, showed to be an alternative clinical tool able to reduce the dentinal permeability.**

INTRODUCTION

APICAL SURGERY PROCEDURE has been done as an attempt to eliminate problems caused, or not solved by endodontic treatments. This surgery is considered a therapeutic alternative for patients with calcified or perforated root canals, as well as for those with contaminated canals and a high level of complicated root anatomy, non-removable root pins[1] and mainly with for root canals a stable bacterial colonization which is refractory to conventional endodontic treatment.[2] Facing endodontic treatment failure, a new treatment is indicated; however, when not feasible, the surgical apical procedure is performed.[3]

Molven et al.,[4] under scanning electron microscopy (SEM) examination of the apical root canals portion with periapical lesions removed by apicoectomy, observed the presence of bacteria, 2 mm from the apical root, in 83% of the cases. The presence of microorganisms in the root canal system could cause a migratory flow into the periapical region which makes the retrofill a routine procedure in apical surgeries.[5]

The aim of endodontic surgery is to remove the critical apical portion of the root canal and to promote an apical sealing of the root canal system and consequently to obtain an efficient barrier for microorganisms of their by-products avoiding percolation to the periapical tissues.[6]

The Er:YAG laser system, with 2.94 μm wavelength, is able to promote ablation of oral hard tissues effectively, as it is highly absorbed by water and hydroxyapatite.[7–9] In 1996, Gouw Soares et al.[10] showed, through SEM, that such wavelength

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promotes, after apicoectomy a clean cut surface with evidence of dentinal tubules without smear layer, no structural injury, no cracks and no fissures.

Maillet et al.[11] suggested the Nd:YAG laser as a potent tool to optimize apical surgical treatment. Its irradiation promotes melting on dentin surface, which may result in obliteration of dentinal tubules and decrease of permeability. These effects could reduce apical microleakage, which is one of the major factors associated with periapical surgery failures.

The laser is currently known as an important tool for biomedical applications. As it is a new dentistry therapeutic approach and feasible to perform periapical surgeries, it is important to point out its further scientific investigation in order to substantiate the use of such an important resource.

MATERIALS AND METHODS

The specimens were mechanically instrumented with endodontic files (Kerr), Endo PTC and irrigated with 2.5% sodium hypochlorite solution. Afterwards, root canals were dried and obturated with laterally condensed gutta-percha and N-Ricket cement and, then, stored in saline solution 0.9%.

Samples were randomly divided into three groups with eight specimens each, specified as follows:

- Group I: Apicoectomy with Er:YAG (350 mJ; 4 Hz; 28.2 J/cm^2); treatment of the cut dentinal surface (120 mJ; 4 Hz; 69.1 J/cm^2) and preparation of the retrocavity (350 mJ; 4 Hz; 201.5 J/cm^2) with Er:YAG laser through optical fiber 50/10
- Group II: Apicoectomy similar to Group I, treatment of cut dentinal surface (100 mJ; 15 Hz; 1.5 W) and retrocavity preparations (100 mJ; 15 Hz; 1.5 W) with Nd:YAG laser
- Group III (control): Apicoectomy and retrofill were performed with high-speed burs

All the roots were resected perpendicular to its long axis 2 mm from the apex, dentinal surface treated, retrocavity prepared and filled with IRM. The external surfaces of the specimens were covered with three layers of nail-polish. Only the dentinal cut surfaces were exposed to the methylene blue dye. The specimens were immersed into 0.5% methylene blue dye, pH 7.2, for 48 h at 36°C. Dye excess was then removed under tap water for 30 min.

The apical portion of the specimen was resected into five slices of 1 mm thickness size from the apex to the cervical direction, using a diamond disc with water coolant. The first slice was submitted to SEM examination (Philips, Model XL 30), and four others were prepared for optical microscopic observation of the dye penetration.

RESULTS

Optical microscopy

The apical dye penetration was observed along the interface between the root dentinal wall and the gutta-percha, as well as through the cut dentin surfaces.

TABLE 1. SURVEY OF THE RESULTS: MEANS, STANDARD DEVIATIONS, MINIMUMS, AND MAXIMUMS

Group	*Mean*	*SD*	*Minimum*	*Maximum*
I	1.12	0.26	0.68	1.66
II	0.95	0.16	0.71	1.18
III	1.33	0.21	1.05	1.55

Means and standards deviation were calculated for all of the slices. Data analysis was done using the Tukey test.

Group I, apicoectomy with Er:YAG (350 mJ; 4 Hz; 28.2 J/cm^2); treatment of the cut dentinal surface (120 mJ; 4 Hz; 69.1 J/cm^2) and preparation of the retro cavity (350 mJ; 4 Hz; 201.5 J/cm^2) with Er:YAG laser through the optical fiber 50/10, showed a lower infiltration level when compared with Group III (control); however, it was not statistically significant (the descriptive mean of dye penetration was 1.12).

Group II (apicoectomy analogous to Group I; treatment of cut dentinal surface (100 mJ; 15 Hz; 1.5 W) and cavity preparations for the retrograde filling (100 mJ; 15 Hz; 1.5 W) and Nd:YAG laser presented the lowest infiltration level of methylene blue dye when compared with the other experimental groups (the descriptive mean of dye penetration was 0.95).

In Group III (control group), the descriptive mean of dye penetration was 1.33.

The samples irradiated with Er:YAG and Nd:YAG laser of the group II showed the lowest infiltration indices when statistically compared to the specimens from GII and GIII.

Scanning electron microscopy (SEM)

Scanning electron microscopy examination of the specimens from Group I, Er:YAG laser irradiation through the fiber 50/10 (120 mJ; 4 Hz; 201.5 J/cm^2) showed structural alterations with a clean surface, evidence of dentinal tubules, without smear layer, cracks, fissures or melting of dentin. The formation of some craters when the fiber 50/10 was used during the cut

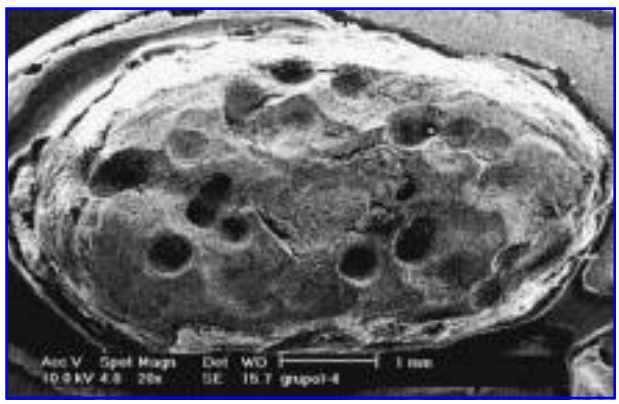


FIG. 1. Aspect of the dentinal cut surface of a specimen from Group I after Er:YAG laser irradiation through the optical fiber 50/10.

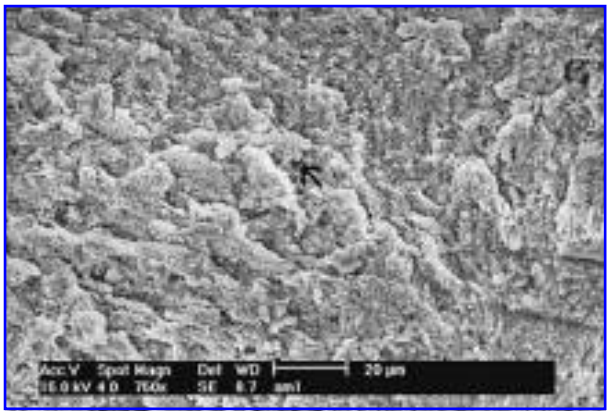


FIG. 2. The same surface of Fig. 1 under higher magnification, showing evidence of dentinal tubules.

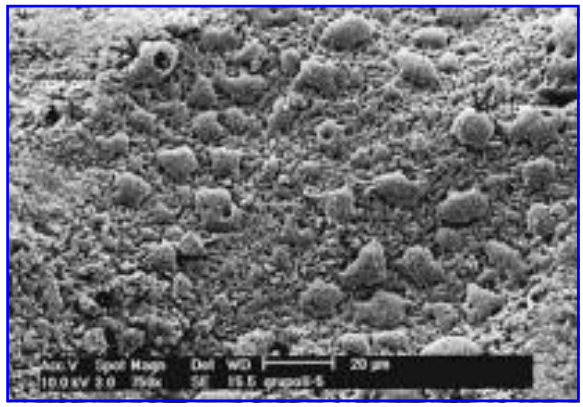


FIG. 4. The same surface as in Fig. 3 under higher magnification, showing melting and recrystallization of the dentine structure.

dentinal surface irradiation (Figs. 1 and 2) can also be observed. Photomicrographs of the dentin surfaces from specimens of the G II, after Nd:YAG laser irradiation (100 mJ; 15 Hz; 1.5 W) were clean, with no smear layer, and with sealed, dentinal tubules with melting, resolidification and recrystallization areas alternated with non irradiated areas (Figs. 3 and 4).

DISCUSSION

Generally, the failures of the surgical endodontic treatment are due to the presence of microorganisms associated with the permeability of the dentinal tubules exposed of the cut surface. For this reason, the elimination or maximum reduction of microorganisms in the apical region,[12] is extremely important for a successful treatment. It is also important to obtain a smooth, regular and not permeable resection surfaces.[13,14]

An apical resection performed by high-speed burs produces a cut surface covered by smear layer, which represents a continuous presence of microorganisms in the apical region.[15]

In vitro studies of apicoectomies using the laser irradiation have been conducted to obtain a smoother and less permeable cut dentin surface producing the melting and recrystallization of the dentinal structure with the closure of dentinal tubules.[10,12,14–17]

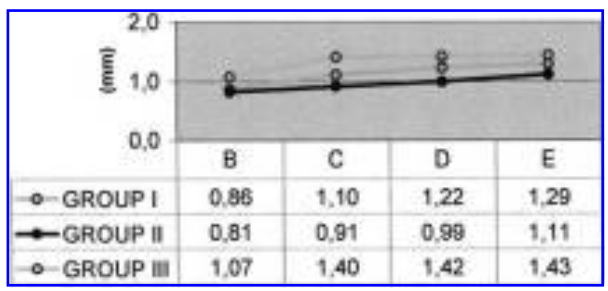
Irradiation with high-intensity lasers have been shown to produce bacterial reduction,[18–20] which is vitally important in apical surgeries, as the presence of microorganisms and its by-products make tissue healing difficult, leading to treatments failures.

Authors[21] have reported the association of three wavelengths in the clinical procedure of apicoectomy. The root resection performed with Er:YAG laser, bacterial reduction in the bone cavity surrounding all of the infected area through a fiber of the Nd:YAG laser as well as the obliteration of the dentinal tubules with this same Nd:YAG laser, followed the use of a Low Intensity Laser Therapy using a Ga-Al-As laser irradiation.

The fiber 50/10 used for sealing the apex with the Er:YAG laser (KaVo KEY 2), under the conditions of the present work, was not to promote obliteration of the dentinal tubules. Therefore, further studies, in order to find suitable parameters that would promote such effect, are necessary.

For the current study, the associated use of Er:YAG laser for apicoectomy and Nd:YAG laser for the treatment of the cut dentinal surface as well as for the retrocavity may be consid-

FIG. 3. Dentine surface of a sample from Group III resected with Er:YAG and surface treated with Nd:YAG laser.



	B	C	D	E
GROUP I	0,86	1,10	1,22	1,29
GROUP II	0,81	0,91	0,99	1,11
GROUP III	1,07	1,40	1,42	1,43

FIG. 5. Mean values of the microleakage indexed of each group.

ered a clinical alternative tool as an attempt to seal the dentin surface, avoiding percolation between the canal system and apical region. This result is in accordance with others reports,[10–12,14–17,21] in which the authors show the sealing obtained through the Nd:YAG laser irradiation.

CONCLUSION

In this study, the samples irradiated with Er:YAG laser for apicoectomy and Nd:YAG laser for dentine treatment showed the lowest infiltration indices when statistically compared to the specimens from GI and GIII.

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