

# ND:YAG LASER INTERACTION WITH THE ELECTRICAL CONDUCTANCE MEASURED AT THE ROOT CANAL LEVEL

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## REZUMAT

**Obiective:** Acest studiu preliminar și-a propus să determine modificările conductanței electrice la nivelul canalului radicular iradiat cu laser Nd:YAG. **Material și metode:** În cadrul studiului s-a folosit 40 de rădăcini, cu un singur canal radicular, provenind de la dinți proaspăt extrași. După stabilirea lungimii de lucru s-a efectuat instrumentarea endodontică manuală a canalului radicular prin tehnica step-back, cu ace de mână tip K, până la o mărime apicală master corespunzătoare pilei nr. 40. Sigilarea apexului s-a realizat cu ionomer fotopolimerizabil și cu lac izolator. S-a determinat conductanța electrică inițială. Suprafața canalelor radiculare a fost expusă la radiație laser utilizându-se laserul Nd:YAG (mod VSP; 1,5W; 15Hz). După iradiere s-a determinat conductanța electrică finală. Pentru determinările conductometrice a fost utilizat Conductometer OK-112, ce a fost cuplat la 2 electrozi de platină, unul introdus 5 mm în canalul radicular, iar celălalt atașat la suprafața radiculară externă. Valorile conductanței au fost achiziționate digital la un interval de 1 minut, timp de 30 de minute.

**Rezultate:** Pentru fiecare probă au fost măsurate valorile conductanței electrice inițiale și finale, modificarea conductanței fiind exprimată procentual. În urma analizei întregului lot de rădăcini s-a constatat o creștere a conductanței electrice, exprimată procentual de aproximativ 250%. **Concluzii:** Modificarea marcantă a valorii medii procentuale a conductanței electrice, în condițiile în care nu au loc modificări semnificative ale geometriei peretelui dentinar radicular măsurat, indică îndepărtarea unui strat cu conductanță electrică redusă.

**Cuvinte cheie:** conductanță electrică, canal radicular, laser Nd:YAG

## ABSTRACT

**Objectives:** This preliminary study aims to present the changes in electrical conductance in the root canal when irradiated with Nd:YAG laser. **Material and methods:** 40 straight roots with one root canal each, from freshly extracted teeth, were used in this study. After determining the working length, the root canals were instrumented manually using the step-back technique up to a size 40 K file. External apex sealing was performed with a light curing glass-ionomer and an insulator coater. The initial electrical conductance was registered. The surface of root canals was exposed to laser irradiation, using the a Nd:YAG laser (VSP mode 1.5W, 15Hz). The final electrical conductance was measured after irradiation. The OK-112 Conductometer was used for conductance measurements, connected to two platinum electrodes, one introduced 5 mm inside the root canal, and the second attached to the external root surface. Conductance values were recorded digitally every 10 seconds, for 30 minutes. **Results:** The initial and final electrical conductance values were measured for each sample, and the changes in conductance were expressed as percentage. Following the analysis of the entire lot of roots, an increase in the electric conductance was observed, expressed percentually as 250%. **Conclusion:** The increase in the average percentual value of electrical conductance, when no significant changes of the geometry of the measured dentinal wall occur, indicate an change in the electric properties of the structure measured, which can be associated with removing a low-conductance layer and/or the increase in the electrolyte quantity in the structure studied.

**Key Words:** electrical conductance, root canal, Nd:YAG laser

## INTRODUCTION

Electrical conductance, a term coined in 1885 by Oliver Heaviside, is the reciprocal of electrical resistance. It is a measure of how easily electricity flows along a certain path through an electrical element.

Studies regarding measurements of electrical conductance changes of human dental structure date back to 1931, and were focused on enamel permeability.<sup>1</sup> Electrical conductance measurements are currently employed in caries diagnostic and have been evaluated in a number of in vitro and in vivo studies.<sup>2</sup>

This preliminary study aims to present the changes in electrical conductance after Nd:YAG laser irradiation of the root canal.

## MATERIALS AND METHODS

Forty recently extracted human maxillary anterior teeth with a single, straight root canal were selected for this study. Roots with cracks, open apices, resorptive defects or large carious lesions approaching the pulp

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have been excluded. After removal of bony debris, calculus and soft tissue on the root surface, the teeth were stored in deionized water at 40°C until use.

The coronal portion of all teeth was removed with a diamond disk so that each specimen was 8 mm long.

### Endodontic preparation

Root canal preparation was performed on all roots by a single operator. After removal of the pulp tissue, a size 15 K-type file was introduced into the root canal until the tip was just visible at the major apical foramen. The working length was determined by subtracting one mm from this length. The root canals were instrumented manually using the step-back technique up to a size 50 K file. Irrigation was performed with 2.5% sodium hypochlorite solution after each instrumentation. The canals were dried with paper points and external apex sealing was performed using a light curing glass-ionomer and an insulator coater.

All roots were stored in saline solution (0.9% NaCl) for 24 hours.

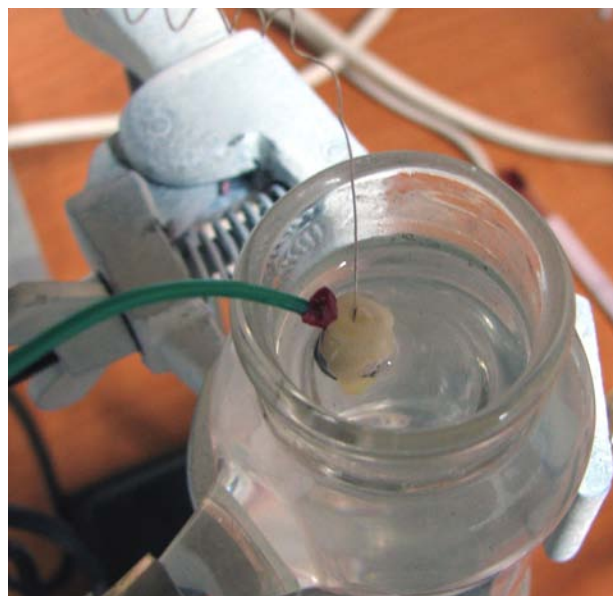
### Electrical conductance measurements

A platinum electrode (5x5 mm<sup>2</sup>) was attached to the external root surface and connected to the OK-112 Conductometer. The root was immersed 7 mm in a electrolyte solution, thermostated at 37°C (0.9% NaCl). The second platinum electrode (5 mm wire) was introduced completely in the root canal. (Figs. 1,2)

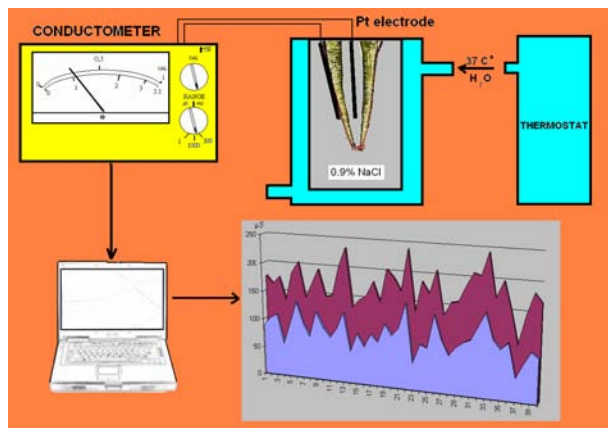


**Figure 1.** The OK-112 Conductometer device used in this study.

Conductance values were registered digitally every 10 seconds for 30 minutes, before and after laser irradiation. Figure 3 shows a schematic representation of the entire system used for electrical conductance measurement.



**Figure 2.** Sample measurement.



**Figure 3.** Schematic representation of the entire system used for electrical conductance measurement.

### Laser irradiation

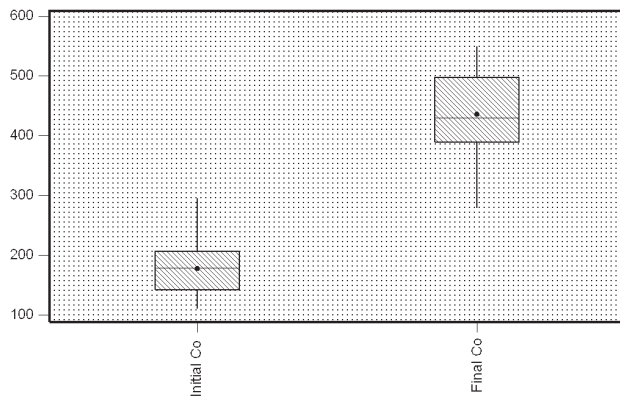
Laser treatment was performed on all roots by a single operator. The surface of the root canals was exposed to laser irradiation using a Nd:YAG laser (Fotona Fidelis Plus II). Parameters used are listed in Table 1. Irrigation with sodium hypochlorite solution was performed after each laser exposure. The external platinum electrode was kept in place during the laser procedure.

**Table 1.** Laser treatment parameters.

Mode	VSP
Power	1.70 W
Frequency	15 Hz
Treatment time	5 sec./exposure
No. exposures/procedure	3
Optical fiber diameter	200 micrometers

## RESULTS

The statistical analysis, performed using the MINITAB software, demonstrated an increase of electrical conductance after Nd:YAG laser irradiation ( $p < 0.005$ ). (Figs. 4,5)



**Figure 4.** Boxplot representation of the results of statistical analysis (means are represented by solid circles).

### One-way ANOVA: Initial Conductance, Final Conductance

Analysis of Variance					
Source	DF	SS	MS	F	P
Factor	1	1305491	1305491	371.96	0.000
Error	76	266742	3510		
Total	77	1572233			

Individual 95% CIs For Mean Based on Pooled StDev			
Level	N	Mean	StDev
Initial Co	39	177.69	46.62
Final Co	39	436.44	69.61

Pooled StDev = 59.24

**Figure 5.** The results of the One-Way ANOVA statistical analysis ( $p < 0.005$ ).

## DISCUSSIONS

The increase of electrical conductance is associated with the permeability increase of the layer comprised between the electrodes for sodium and chloride ions. In the root canal, this phenomenon may occur due to: the increase of the intracanal surface area and the decrease of root dentin thickness.<sup>3-5</sup> However, no significant changes in the geometry of the measured dentine wall occur during endodontic laser irradiation. Consequently, an increase in dentine permeability may be explained by the previous removal of smear layer, resulting in open dentinal tubules with the penetration of the electrolyte solution into these dentinal tubules.

Many efforts have been made to remove the smear layer and debris from the root canal.<sup>6</sup> A number of laser systems were employed in the endodontic treatment: Nd:YAG, Argon, Diode and Er:YAG.<sup>7,8</sup> Many reports on Nd:YAG laser irradiation of the root canal were published.<sup>9,10</sup> It was shown that debris and smear layer were removed using appropriate Nd:YAG laser parameters.

The majority of studies focused on investigating root canal surfaces after laser treatment used Scanning Electron Microscopy (SEM). This method of analysis of the canal walls permits a direct correlation between the variation of permeability and the amount of surface covered with smear layer or organic debris. There is an inverse relationship between the variation of dentine permeability and the presence of smear layer.<sup>4</sup>

There is no data suggesting measurements of electrical conductance in root canals. In our study this new method was used to assess changes of the electrical properties of the root canal after Nd:YAG laser irradiation. Therefore, a comparative SEM study would be necessary to confirm the results.

The working protocol of this study employed certain measures in order to minimize external influences that may affect the accuracy of the findings. Platinum electrodes were employed to prevent polarization. The square external electrode was kept in place during laser procedures to avoid measurement errors that may occur due to different positioning. The electrolyte solution was thermostated at  $37^{\circ}\text{C} \pm 0.5$  in order to prevent the variation of conductance with temperature.<sup>11</sup>

## CONCLUSIONS

Under the conditions of this in vitro study, it can be concluded that Nd:YAG laser irradiation induce electrical conductance changes, which can be associated with increased permeability for sodium and chloride ions. This findings can be correlated with Nd:YAG laser capacity to remove smear layer.

The advantage of the method employed in this study is the simplicity and easiness of samples preparation and measurement.

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