AN EVALUATION OF THE 980 NM GAALAS HIGH-LEVEL DIODE LASER IN THE TREATMENT OF DENTINE HYPERSENSITIVITY

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INTRODUCTION

Dentinal hypersensitivity represents a frequently encountered oral condition of patients in the dentist's office, which raises problems in identifying the primary etiological factor, as well as of therapeutic attitude.¹ The studies conducted, concerning the prevalence of this condition, showed that women seem to be more affected than men, probably due to general health condition and to a better maintained oral hygiene,dentinal hypersensitivity occurring more frequently at the end of the third decade of life and the beginning of the fourth.²⁻⁵

As agreed upon by the majority of authors, dentinal hypersensitivity is defined as pain arising from exposure of the dentine, as effect of application of a thermal, chemical, tactile or osmotic stimulus, and which cannot be explained as being caused by other flaws or dental pathology.⁶⁻⁷ The recent modification of this definition consists in replacing the term


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“pathology” with that of “illness”, in order to avoid any confusion with other conditions, as it is, for example, the atypical odontalgia.8

The causes that lead to exposure of the dentine can be multiple, but the common distinctive element of the exposed dentine is represented by the opening of the dentinal tubules that makes direct contact between the external and the internal environment, the dental pulp.9 Studies of electronic microscopy trough transmission and scanning showed that in the area affected by hypersensitivity the structure of the dentine is altered, containing a high number of dentinal tubules with a tubular diameter much higher than in the non-affected areas.10-12 Many theories have tried to explain the producing mechanisms of dentinal hypersensitivity, such as the odontoblastic transduction theory, the neuronal therapy, and the hydrodynamic theory.13-17 Presently, however, the hydrodynamic theory proposed by Brännström and his collaborators is the most accepted one.17-20 This theory postulates that the dentinal hypersensitivity is determined by the hydrodynamic movement of the fluid that appears in the open tubules of the exposed dentine, this movement activating mechanically the nervous fibers situated at the external extremity of the dentinal tubules or in the interior layer of the pulp. The movement of the tubular fluid are determined by the direct action of the external temperature, mechanic, chemical or osmotic stimuli. The thermic expansion coefficient of the tubular fluid is almost ten times higher than that of the tubule wall.21 Thus, the heat applied to the affected dentine will determine the expansion of the tubular fluid and the cold will determine the contraction of the fluid, both mechanisms causing an excitation of the mechanoreceptors.

The dentinal hypersensitivity treatment is widely varied and complex, the treatment strategy being different for each individual case, according to the etiological factors.

In practice, we aim to prevent the direct contact between the external stimuli and the tubular fluid, mainly by closing the dentinal tubules. If the diagnosis of dentinal hypersensitivity was confirmed, in the absence of other structure lesion of the tooth or general ailments of the patient, the therapeutic attitude is the following: (a) the removal of risk factors by educating the patient to avoid an acid diet and performing a correct oral hygiene; (b) the correction of the unhealthy habits and/or of parafunctions; (c) instructing on a correct teeth-brushing; (d) the initiation of the desensitizing treatment by recommending the use of desensitizing agents at home; (e) professional application of certain local desensitizing methods.6-8,22

This last therapeutic attitude is performed by the specialist in the dentist’s office and consists either in using different topic agents or in the application of certain therapeutic procedures that can be invasive or non-invasive. The present study has a purpose to determine the effectiveness of the 980 nm GaAlAs diode laser therapy (HLLT) in reducing the dentinal hypersensitivity to cold thermic stimulus.

**MATERIAL AND METHODS**

**Subjects**

The study group consisted of 12 patients who presented at least two monoradicular teeth affected by cervical dentinal hypersensitivity of second or third degree. The patients were selected out of a number of 87 patients of the Department of Oral Rehabilitation and Dental Emergencies. The subjects, aged between 18 and 37 years were in good general health condition and could attend the appointments until the end of the study. The “in vivo” study was made under the approval of the Local Ethics Committee and the patients signed a written agreement to participate in this study, after having been informed about the study protocol.

The selection criteria, as well as the running of the study, were chosen in accordance with the American Dental Association (ADA) Guidelines for the Acceptance of Products for the Treatment of Dentinal Hypersensitivity.23 The exclusion criteria of the teeth included in the study were represented by:

- Anterior professional desensitising treatment;
- Chronical use of anti-inflammatories, pain killers and psychotropic drugs;
- Pregnancy, allergic manifestations idiosyncrasies to various products;
- Food-related syndromes associated with regurgitation;
- Etiological conditions that determine or predispose to dentinal hypersensitivity;
- Acid-rich diet or exposure to acids;
- Parodontal surgery or orthodontic treatment in the last three months;
- Dental or parodontal pathology or which predispose to pain occurrence;
- Teeth with conservative treatments in the last three months;
- Pillar teeth of fixed or mobile dentures;
- Teeth having unidental prosthetic works;
- Teeth having large obturations and/or which extended also in the area that was to be tested.

From the selection moment and until the...
beginning of the tests a standardized oral hygiene was established. During this period no products for dentinal desensitization were used.

The Laser Source

The laser used in this study was Ga-Al-As Biolitec ($\lambda = 980$ nm), as shown in Figure 1; the parameters used are presented in Table 1.

<table>
<thead>
<tr>
<th>GaAlAs diode laser parameters:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda$ wavelength</td>
<td>980 nm</td>
</tr>
<tr>
<td>Operation mode</td>
<td>continuous</td>
</tr>
<tr>
<td>Power</td>
<td>0.5W</td>
</tr>
<tr>
<td>Energy/Application</td>
<td>15J</td>
</tr>
<tr>
<td>Exposure time/Application</td>
<td>30 sec.</td>
</tr>
<tr>
<td>No. of applications / session</td>
<td>1</td>
</tr>
<tr>
<td>No. of sessions</td>
<td>3</td>
</tr>
</tbody>
</table>

Installation for producing the standardized thermal stimulus

In order to apply a constant and reproducible thermic stimulus, an installation was conceived, as follows: on a Braun-Melsungen type 871012 injectomat a 100 ml BD Plastipak syringe was installed, to which a Romed perfusable device was attached. To the latter, a 'T' shape (sterilized) glass tube was adapted with the purpose of measuring the fluid temperature in a real time. Inside the ramified glass tube there was set a K type thermocouple which had direct contact with the fluid flux. The injectomat was set on a constant flow of 0.15 ml/s, at a temperature of $5^\circ$C. In order to read the temperature, a digital HI98801 KJT Printing thermometer was used. At the end of the perfusable device there was fixed a sterile syringe needle with a 0.7 mm in diameter. (Fig. 2) We mention that for every patient we used syringes, needles and perfusable kits of single use only.

Figure 2. The layout of the cold thermic stimulus standardization device.

Other materials used were: an infrared thermometer (IR) – Microlife with ± 0.2°C resolution; a thermistor as temperature sensor (KTY); a computer system for collecting and processing the data; insulation material. The data was processed using SPSS version 15.0 software.

The working technique

For every patient in the study, the two single-rooted teeth having cervical dentinal hypersensitivity were submitted for the treatment differently. Thus, one tooth was treated with laser diode, while the second tooth was considered control and underwent the placebo effect, being irradiated with a guiding beam of the diode.

For all the subjects included in the study, one doctor recorded the surface temperature of the tooth, both before and after the laser exposure therapy, another specialist performed the exposure of the tooth to the laser radiation and another operator gathered and processed the data.

The work protocol was as follows:

At the first visit, we took the correct history of the patients and we recorded the initial level of dentinal hypersensitivity to cold, for each selected tooth with cervical dental erosion. To this purpose, each tooth was insulated with rolls and the standardized cold stimulus was applied, the pain response of the patient being recorded and quantified on an ascending scale of 1 to 4 (0-absent, 1-discomfort, 2-slight pain, 3-moderated pain, 4-severe pain). The pain sensitivity values ranged between 2 and 3 for all the teeth included in the study, according to the selection criteria.
At the second visit, every patient sat comfortably on the dentist’s chair, the ambient clinic temperature was approximately 21°C, and the lamp from the dentist’s unit was positioned at a distance between 45 and 55 cm from the patient. For each tooth included in the study the following determinations were made, 30 minutes before and 30 minutes after the laser therapy irradiation: the surface temperature of the tooth, the pain sensitivity level and the time elapsed to pain occurrence.

Thus, each tooth was insulated and the surface temperature was recorded with the help of the infrared multiscan thermometer and of the KTY thermistor, applied on the vestibular surface of the tooth in its middle third. (Fig. 3)

![Figure 3. Recording the surface temperature of the tooth using the infrared thermometer and the thermistor.](image)

Then, we applied a standardized cold stimulus, distilled water cooled at 5°C, which irrigated the tooth under a constant flux of 0.15 ml/s, continuing recording the surface temperature of the tooth until 60 seconds after the occurrence of pain sensitivity. After 30 minutes the laser therapy was applied to the worked teeth, obeying the presented parameters and placebo treatment to the witness teeth. (Fig. 4)

![Figure 4. The 980 nm GaAlAs diode laser therapy on the affected area.](image)

Thirty minutes after the irradiation the thermal stimulus was again applied and the three parameters concerned were recorded, according to the work protocol presented.

In order to gather and process the values of the surface temperature of the tooth when using the KTY type thermistor, a PC system for gathering and processing the data was adapted. (Fig. 5)

![Figure 5. The recording and processing of the data referring to the surface temperature of the tooth.](image)

On the third and the fourth visit the same protocol was followed as for the second visit, with a three-day break between the sessions. Visit 5 and 6 were performed after a week and after a month respectively, new recordings of the surface temperature were taken in the conditions of applying the standardized thermal stimulus.

**RESULTS**

The recorded results highlighted that the occurrence of the dentinal pain is directly dependent on the feel of the tooth temperature and the threshold of the painful sensitivity, characteristic for each patient. The average temperature, before the laser therapy, at which the pain sensation occurred was of 22.1°C and the average temperature at which the pain sensitivity occurred (with a low intensity) after the 980 nm GaAlAs laser irradiation, was of 19.2°C. (Table 2)

We were particularly interested in comparing the average values of the surface temperature of the teeth recorded, when tested with standardized cold stimulus, before the first exposure and the ones recorded, when tested with the same stimulus, after a week, respectively a month after the end of the treatment. Thus, a significant reduction of the average values recorded can be observed after a week and after a month, with a slight increase after a month compared to those after a week. (Table 2)
Table 1. The descriptive statistics for the surface temperature values recorded with the thermistor sensor (KTY) and the IR thermometer. The values measured with KTY at the beginning and the end of treatment (Visit 1 and Visit 5) are on grey background.

<table>
<thead>
<tr>
<th>Measured Parameter</th>
<th>No. of</th>
<th>Domain</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Standard Error</th>
<th>Standard Deviation</th>
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</table>

Figure 6. Average values of the surface temperature recorded 30 minutes before the laser therapy (session 1), sessions 2, 3, and 4.

In Figure 6 we can observe the first line (series 1), which shows the surface temperature of the tooth when applying the standardized cold stimulus 30 min before the first laser exposure. Furthermore, the second line (series 2) shows the evolution of the surface temperature of the tooth when applying the cold stimulus 3 days after the first laser exposure, the third line (series 3) shows the same thing 3 days after the second exposure and the fourth line (series 4) shows the evolution of the surface temperature of the tooth a week after the third exposure.

The recordings of the surface temperature of the teeth shows that the pain sensitivity occurs at lower and lower surface temperatures of the tooth (Fig.6).

The measurements were not independent but clearly related to each other for the same subject. The descending trend in the evolution of the temperature at which the sensation of pain occurs is apparent in Figure 7, in spite of the inherent variation from one patient to another.

Figure 7. The descending trend in the temperature at which the sensation of pain occurs during the laser treatment. The values of the surface temperature were recorded with the thermistor (KTY), 30 min before the laser exposure (cold1, cold2, cold3, cold4), 30 min after the exposure (laser1, laser2, laser3, laser4), and a week, respectively a month after the treatment (cold5).
Therefore, in order to analyze this trend, we used a general linear model, the repeated measures design. We employed the Hotelling’s $T^2$ test, a special case of the multivariate analysis of variance (MANOVA), to process this data set with one independent variable (the treatment, i.e. the laser exposure) and more dependent variables (the repeated measures of the temperature threshold for pain sensation).

After applying the multivariate analysis (Hotelling’s $T^2$) we concluded the decrease in the dentinal sensitivity was statistically significant ($p<10^{-3}; F = 113.778, df1 = 4.00, df2 = 8$). Moreover, the effect was proved to last, as we also included in our analysis values collected one month after the treatment.

**DISCUSSIONS**

So far, the majority of studies referred to the use of GaAlAs diode laser for reducing the dentinal hypersensitivity used various wave length (780, 830, 900 nm) of the diode but not the one of 980 nm. In this preliminary study we wanted to see whether the 980 nm GaAlAs diode laser had the capacity to modify the dentinal sensitivity and in what way.

Although it has been recommended by some authors to use more than one stimulus, we chose to use a single stimulus, deionised water cooled at 5°C, because this seemed to be a clinically relevant measure and the cold stimulus is the most frequently responsible for producing dentinal hypersensitivity. Also, in order to reduce the possibility of error occurrence when obtaining the results, we aimed at using a constant cold stimulus and for this purpose a device was built. (Fig. 2)

During this study there was used a very homogenous group of patients, who strictly obeyed their diet and the oral hygiene indications all throughout the study and who were able to attend all the testing sessions. This explains the highly statistically significant results obtained.

The recordings made in this study showed that the physiological temperature of the teeth differs from one patient to another and even from one tooth to another, concurring with the results obtained by other researcher. Therefore, correlations between the time (elapsed from the application of the cold stimulus until the occurrence of the pain sensitivity) obtained before the laser exposure and the one recorded after the laser treatment can be made only for each individual tooth. In other words, the dentinal pain was directly dependent on the lowering of the tooth temperature and the threshold of the pain sensitivity, characteristic for each patient.

In case of the teeth exposed to the 980 nm GaAlAs laser radiation action, the measurement of the surface temperature of the tooth during the irradiation shows an obvious and rapid rise of approximately 1°C.

The recordings made 30 minutes after the laser radiation emphasized a high hypersensitivity of the teeth, with the following clinical meaning:

- Hypersensitivity at a surface temperature of the tooth higher than the one before the irradiation;
- Pain sensitivity felt and expressed by the patient, in a shorter time than in the recordings made before the exposure;
- The reduction of the sensitivity threshold.

Instead, the recordings made in the sessions 3 and 4, 30 minutes before the exposure to the laser radiation, as well as those made after a week and after a month from the laser exposure, showed:

- The dentinal hypersensitivity occurred at a lower teeth temperature than at the initial determinations;
- The dentinal hypersensitivity was reduced in intensity;
- The threshold of the dentinal sensitivity rises.

The recordings of the surface temperature of the teeth included in the work group, with the help of the KTY temperature sensor, clearly shows that after three days from each exposure, the exposure time to cold stimulus rises and the dentinal hypersensitivity appears at lower and lower teeth temperatures.

Also, the recorded values for the witness teeth group did not present any significant evolutions from one session to another.

**CONCLUSIONS**

In conclusion, the 980 nm GaAlAs diode laser therapy induced a clinical reduction of the dentinal hypersensitivity after each laser application and a significant reduction from the statistic point of view of the values of the surface temperature of the teeth recorded at the end of the treatment compared to those at the initial visit.

The installation made for the standardization of the cold thermal stimulus permitted the production of such a stimulus and at the same time can be used for the standardization of other stimuli in liquid state (osmotic, pressure, pH).

In this preliminary study we demonstrated that the treatment was efficient, that is, worked in ideal conditions. However, a randomized study is necessary in order to prove the 980 nm GaAlAs laser therapy also works in real conditions.
REFERENCES


