

# Clinical Evaluation of Middle Power Output 810 nm GaAIAs Diode Laser for Treating Severe Dentin Hypersensitivity: A Randomized Clinical Trial

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## ABSTRACT

**Aim:** To evaluate the clinical efficacy and longevity of middle power output 810 nm gallium-aluminum-arsenide (GaAIAs) diode laser in the treatment of severe dentin hypersensitivity.

**Materials and methods:** Forty patients were selected having severe hypersensitive teeth corresponding to 7 and above on the visual analog scale (VAS). Dentin hypersensitivity (DH) was assessed by tactile and thermal stimuli and measured by VAS. Teeth were randomly divided into two groups—treatment group (treated with GaAIAs diode laser) and control/placebo group (treated with curing light). In the treatment group, the laser used was a 810 nm GaAIAs diode laser, having a power of 0.5 W and for a duration of 2 minutes. Patients from both the groups were subjected to three sessions for treatment of dentin hypersensitivity, at intervals of 0 hours, 24 hours and 48 hours. Dentin hypersensitivity was measured before and after each session and again evaluated after 12 weeks.

**Results:** In both the groups, mean values at 0, 24 and 48 hours showed a significant reduction in VAS scores ( $p$ -value  $< 0.05$ ). Intergroup comparison showed that reduction in VAS scores was significantly more in the laser treated group. However, at 12 weeks evaluation, mean reduction in VAS scores decreased in the treatment group indicating recurrence of hypersensitivity.

**Conclusion:** Within the limitations of this study, it may be concluded that GaAIAs middle power output diode laser is effective in providing immediate relief in severe cases of dentin hypersensitivity although long-term results show recurrence of dentin hypersensitivity.

**Keywords:** Middle power output diode laser, Dentin hypersensitivity, Visual analog scale.

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## INTRODUCTION

Dentin hypersensitivity is one of the most painful and widespread problem in clinical dentistry, the prevalence of which has been reported to vary from 4 to 73% in different studies.<sup>1-3</sup> This condition is characterized by short, sharp pain arising from exposed dentin in response to stimuli, typically thermal, evaporative, tactile, osmotic or chemical and which cannot be ascribed to any other dental defect or pathology.<sup>4,5</sup> Several theories have been proposed to explain the mechanism of dentin hypersensitivity, which are direct innervation theory, odontoblast receptor theory and fluid movement/hydrodynamic theory. Out of these proposed mechanisms, the most accepted is hydrodynamic theory given by Brännström in 1962.<sup>6</sup> This theory is based on the presence and movement of fluid inside the dentinal tubules. According to this theory, dentin hypersensitivity results when stimuli applied to the dentin displaces the fluid inside the dentinal tubules inwardly or outwardly. Fluid movement then promotes a mechanical deformation of nerve endings at the pulp/dentin interface (odontoblastic layer and subodontoblastic layer), which is transmitted as a painful sensation. These stimuli include cooling, drying, evaporation and application of hypertonic chemical substances.<sup>7</sup>

Depending upon the mechanism of action, various desensitizing agents have been recommended to reduce dentin hypersensitivity which include: nerve desensitizing agents (potassium nitrate), agents forming protein precipitates (glutaraldehyde, silver nitrate), agents plugging dentinal tubules (sodium fluoride, stannous fluoride, bioactive glass), dentin adhesive sealers (fluoride varnishes, glass ionomer cement, dentin bonding agents), and homeopathic agents (propolis). Recent advances in the treatment of dentin hypersensitivity include CPP-ACP, portland cement, arginine calcium carbonate and lasers.

For an ideal desensitizing agent, Grossman had listed the requirements as: rapidly acting with long-term effects, non-irritant to pulp, painless and easy to apply, and should not stain the tooth.<sup>8</sup> To date, most of the therapies have failed

to satisfy one or more of the criteria set by Grossman, but some authors report that lasers may now provide reliable and reproducible treatment.<sup>9</sup>

Laser devices used in the treatment of dentin hypersensitivity are divided into two groups: low power-output devices, such as helium neon (HeNe, 6 mW) and gallium-aluminum-arsenide (GaAlAs) semiconductor laser (30-100 mW), and middle power-output devices (0.3-10 W), such as Nd:YAG, CO<sub>2</sub>, Er:YAG, GaAlAs and Er,Cr:YSGG.

Focusing on the role of GaAlAs laser in the treatment of dentin hypersensitivity (DH), both low power output and middle power output GaAlAs laser have been used in the treatment of DH. The low level GaAlAs laser is easy to apply and presents good results and also it has been shown to increase the formation of secondary dentin by the odontoblasts.<sup>10</sup> The effectiveness of low level diode lasers has been investigated by several authors. However, Kimura et al, in his review, concluded that it is necessary to consider the severity of the DH before using the low power GaAlAs laser since it has been seen that, in severe cases, these lasers are less effective.<sup>11</sup>

Middle power output GaAlAs diode lasers have also been shown to be effective in the treatment of DH. Matsumoto et al did a study to evaluate middle power output GaAlAs diode laser in the treatment of mild cases of DH, the results showed that degree of DH decreased from mild to no pain and there was no recurrence after 4 months and he also concluded that its effectiveness is same as that of Nd:YAG.<sup>9</sup> Demi et al in their review said that low output lasers are chosen for the treatment of mild cervical dentin hypersensitivity while the middle output power lasers show the best results in the treatment of severe cases of dentin hypersensitivity although there is not much evidence.<sup>10</sup> Therefore, the purposes of this *in vivo* study were as follows:

1. To evaluate the efficacy of middle power output gallium-aluminum-arsenide (GaAlAs) laser in the treatment of severe dentin hypersensitivity.
2. To evaluate the patients immediate response before and after each of the consecutive laser applications using a placebo as control.
3. To evaluate the longevity of the treatment comparing the achieved results with the initial condition for both groups and between them.

## MATERIALS AND METHODS

### Patient Selection

A total of 40 patients were selected having severe hypersensitive teeth corresponding to 7 and above on the visual analog scale (VAS) in order to standardize the sample. The teeth selected were having noncarious cervical lesion that is abrasion,

abfraction, erosion or gingival recession as the primary etiological factors with absence of occlusal trauma. Patients had not received any professional treatment with desensitizing agents in the previous 6 months and those using any analgesic or anti-inflammatory medicines were oriented to not make use of it 6 hours before hypersensitivity treatment. Exclusion criteria included teeth having caries, mobility, cracks or fractures, extensive and unsatisfactory restorations. After having received oral and written information about the intention and the design of the study, and having signed the informed consent form, the subjects were included in the study.

### Evaluation of Dentin Hypersensitivity

Each selected tooth of each patient received two stimuli, that is a tactile and a thermal in the form a cold stimulus. The tactile stimulus was given by scratching the suspected site of the lesion with the tip of the #5 dental probe (API). The thermal test with cold stimulus was performed by the contact to the hypersensitive surface with a flexible stick applicator, cooled with Endo-Frost (Roeko). Measurement of sensitivity was performed after each stimulus by VAS, which consists of a 10 cm long line, where the ends represent the pain limits which patient can tolerate through an external stimulus, one end represents absence of discomfort and the other represents a severe discomfort caused by certain stimuli. The range of the discomfort on VAS was read as: 0-4—mild, 4-7—moderate and 7-10—severe. Each time the patient was subjected to a stimulus, he or she was requested to point at the interval from 0 to 10 on VAS, a number corresponding to the pain felt. Teeth with severe hypersensitivity were selected and divided by simple random sampling into two groups — treatment group (treated with 810 nm GaAlAs diode laser) and control/placebo group (treated with curing light).

### Treatment

Prior to any therapy, prophylaxis of the region was done using rubber cup, when possible; if prophylaxis was not possible due to sensitivity, a slightly wet cotton ball was used to remove the soft debris from the teeth. The region being treated was isolated using rubber dam and buccal surface of the tooth with gauze before each treatment session. Dentin hypersensitivity was determined on VAS after application of both the stimuli with a time interval of 5 minutes.

In the treatment group, the laser used was a GaAlAs diode laser (Picasso, AMD Lasers, Dentsply International Co) with a wavelength of 810 nm, having a power of 0.5 W and for a duration of 2 minutes, according to the calibration of the laser device. Teeth subjected to laser treatment were irradiated by punctual application of the laser, that is,

application at three points (distal, central and mesial) and with intraoral tip positioned perpendicular to the dentin surface.

For teeth selected in the control group, a curing light (Dentsply) was used as a placebo and each tooth was exposed to the curing light for 2 minutes. A wood tongue depressor was placed over the sensitive area to avoid possible effects from heat produced by the curing light on the pulp tissue.

Patients from both the groups were subjected to three sessions for treatment of dentin hypersensitivity, at intervals of 0, 24 and 48 hours. The painful sensation was measured on VAS before and after all the three sessions, for each stimulus and for both the groups. After the three applications, the patients were recalled for evaluation after 12 weeks. The tactile and thermal tests were again performed in both the groups, and the results were recorded on the VAS.

All collected data, from the first until the re-evaluation session, was subjected to statistical analysis.

### Statistical Analysis

Students t-test was done to evaluate the reduction in VAS scores from baseline and at different intervals of treatment. For comparison between the control and treatment groups, one-way ANOVA test and a post hoc Tukey test were applied to evaluate the longevity of treatment for both the groups.

### RESULTS

The mean VAS values for both the diode laser and the placebo groups before and after the treatment at different time intervals are shown in Figure 1. The mean values at baseline indicate that all the patients selected for the treatment had indicated a pain response of 8 and above on the VAS with a standard deviation of 0.82 for the test group and 0.78 for the control group with p-value being 0.086. Mean values at 0, 24, 48 hours and 12 weeks show a reduction in VAS scores. Table 1 demonstrates the reduction in mean VAS scores for both the groups at different time intervals. One-way ANOVA test was done for intergroup comparison of reduction in VAS scores between the treatment and control groups. The intergroup comparison showed that for the treatment group mean reduction in VAS scores was more than the control

group with p-value being more significant at 0.000 for the treatment group than 0.004 for the control group.

A post hoc Tukey test was done to evaluate the longevity of the treatment comparing the post-treatment results with the initial condition for both the groups and between them. For the treatment group, there was significant reduction in the VAS scores from the baseline and after first application that is 0, 24 and 48 hours and 12 weeks with p-value being significant at 0.000 at all times of evaluation but, for the control group, the mean reduction of VAS scores, though significant with p-value of 0.007 but was less than treatment group at 0, 24 and 48 hours level of evaluation. But, at 12 weeks level of evaluation for the control group, the mean reduction in the VAS scores was not significant with p-value at 12 weeks being 0.49.

Also, for the treatment group at 12 weeks level of evaluation, the result is significant but the mean reduction in VAS scores has decreased; thus, the long-term efficacy of diode laser in treatment of dentin hypersensitivity was not seen.

### DISCUSSION

Tooth hypersensitivity or more precisely dentin hypersensitivity is described clinically as an exaggerated response to non-noxious stimuli and satisfies all the criteria to be

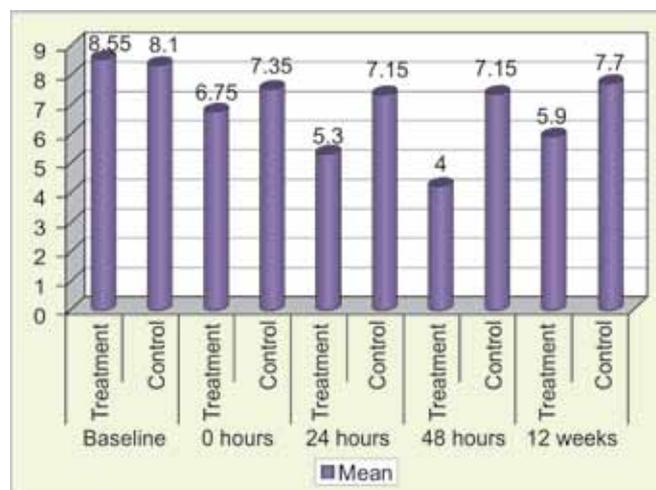


Fig. 1: Mean of VAS scores for both the groups at different time intervals

Table 1: Reduction in mean VAS scores for both the treatment and control groups at different time intervals

Interval		Treatment			Control		
		Mean Difference	SD	p-value	Mean Difference	SD	p-value
Baseline	0 hour	1.80	0.83	0*	0.750	0.71	0.007*
	24 hours	3.25	0.96	0*	0.95	0.75	0.007*
	48 hours	4.55	1.14	0*	0.95	0.94	0.007*
	12 weeks	2.65	1.30	0*	0.40	0.68	0.49, NS

\*Statistically significant; NS: Not significant

classified as a true pain syndrome.<sup>12</sup> Brannstrom et al proposed that dentinal pain is due to hydrodynamic mechanism, i.e. fluid force.<sup>6</sup> The theory is based on the presence and movement of fluid inside the dentinal tubules. Studies have confirmed that the patency of the dentinal tubules is a prerequisite for the sensitivity of exposed dentin. It was shown using scanning electron microscopy (SEM) that teeth with dentinal hypersensitivity have a significantly higher number of patent dentinal tubules per millimeter and a significantly greater mean diameter per tubule than control teeth. The wider tubules increase the fluid movement and thus the pain response.<sup>13</sup>

The management of dentinal hypersensitivity involves the application of therapies that reduce the flow of dentinal fluid or lower the activity of dentinal neurons. To date, most of the reported therapies have failed to satisfy one or more of the requirements for the treatment of dentinal hypersensitivity as recommended by Grossman and, obviously, research in this important therapeutic area is in progress.

A different treatment modality for reducing dentinal hypersensitivity involves the use of laser technology. Maria Demi et al did a review to compare the conventional vs laser treatment of dentin hypersensitivity, they concluded that lasers may provide reliable and reproducible treatment of dentin hypersensitivity.<sup>10</sup> The rationale for laser-induced reduction in dentinal hypersensitivity is based on two possible mechanisms that differ greatly from each other. The first mechanism implies the direct effect of laser irradiation on the electric activity of nerve fibers within the dental pulp, whereas the second involves modification of the tubular structure of the dentin by melting and fusing of the hard tissue or smear layer and subsequent sealing of the dentinal tubules. The lasers used for the treatment of dentinal hypersensitivity may be divided into two groups: low output power lasers (HeNe and GaAlAs) and middle output power lasers (Nd:YAG, CO<sub>2</sub>, Er:YAG, GaAlAs and Er,Cr:YSGG).<sup>9</sup>

In 1990s, semiconductor diode lasers made their debut with several advantages, including their small size, price range and versatility regarding the possible treatment applications.<sup>14</sup> Several authors have investigated the effectiveness of low level diode lasers. Matsumoto et al<sup>15</sup> showed an 85% improvement in teeth treated with laser; Yamaguchi et al<sup>16</sup> noticed an effective improvement index of 60% in the group treated with laser compared to the 22.2% of the control non-laser group. However, Kimura et al in his review concluded that it is necessary to consider the severity of the dentin hypersensitivity before using the low power GaAlAs laser since it has been seen that, in severe cases, these lasers are less effective.<sup>11</sup>

Demi et al in his review said that low output lasers are chosen for the treatment of mild cervical dentin hypersensitivity, while the middle output power lasers show the

best results in the treatment of severe cases of dentin hypersensitivity.<sup>10</sup> As not much evidence is available regarding the efficacy of middle output diode lasers for severe dentin hypersensitivity, the present clinical trial was undertaken to evaluate the efficacy of middle output (0.5 W) 810 nm GaAlAs diode laser in severe cases of dentin hypersensitivity and to evaluate the longevity of the treatment.

Dentin hypersensitivity is a painful condition that is difficult to quantify. In the current study, VAS was used to assess the sensitivity. A VAS test, which has been useful and popular in the fields of psychology, is considered to be good for objective judgment, and this is effective for evaluation of human dental pain.<sup>17</sup> Gillam et al said that VAS if properly explained to the patients, is simple to understand and suitable for use in the evaluation of stimuli response in cervical dentin sensitivity studies. Several investigators compared the VAS with other pain scales and the results indicate that the VAS correlates well with the different testing methods and appears to be more sensitive in discriminating between various treatments and changes in pain intensity.<sup>18</sup>

In the present clinical trial, two stimuli were given, namely tactile and thermal with an interval of 2 to 3 minutes between both the stimuli. All stimuli were given by one operator, with the same armamentarium to standardize the extent of stimulus given. Ricarte et al reviewed the basic protocol for the objective assessment of dentinal sensitivity and suggested that since the sensation produced by the stimulus may differ according to the method employed, it is advisable to use at least two hydrodynamic stimuli. The interval between the stimuli should be long enough to minimize interaction between them and ideally only one investigator be in charge of performing stimulation.<sup>19</sup> Although there are many methods of clinically assessing dentin hypersensitivity, most investigators use either a sharp explorer or a blast of cold air to measure sensitivity which are the oldest and most frequently used methods.<sup>20</sup> Also, a study by Ide M et al<sup>21</sup> indicated good validity for the tactile stimulus.

The results of the present clinical trial demonstrate that middle power output 810 nm GaAlAs diode laser is effective in reducing dentin hypersensitivity in severe cases. The teeth included in the treatment group were submitted to the sequence of treatment established by Bragnera et al according to which after prophylaxis of the region and isolation, application of laser was done with intraoral tip positioned perpendicular to the dentin surface.<sup>22</sup> Since the precise specifications, i.e. the wavelength, power time duration, mode, etc. for using diode lasers are not well clarified; thus, wavelength of the laser device used in this study was 810 nm, at 0.5 W power for a duration of 2 minutes, according to the calibration of the laser device as suggested by the manufacturer and the obtained results showed a clinically relevant reduction in pain sensation.

Effect of laser application was evaluated after first application, i.e. at 0, 24 and 48 hours and 12 weeks follow-up was done to evaluate the longevity of the treatment. The mean VAS scores for treatment group reduced by 1.80 at 0 hours, 3.25 at 24 hours and 4.55 at 48 hours with p-value being significant at all the three levels of evaluation. These results are in agreement with other studies,<sup>9,23</sup> proving the effectiveness of the use of GaAlAs laser for the treatment of dentin hypersensitivity. According to Wakabayashi, there is an increase in the nerve ending threshold for pain, attributed to the maintenance of the receptor membrane potential and the suppression of the nerve ending fiber pulp potential.<sup>24</sup> Kasai et al justified the immediate analgesic effect as a consequence of the interruption of the nerve impulse path in the affected nerve fiber, concluding that laser acts as a reversible suppressor directly on the neuronal activity.<sup>25</sup>

Further, the application of middle power output GaAlAs diode laser provokes surface lasing which causes a melting effect leading to crystallization of dentin inorganic component and the coagulation of fluids within dentinal tubules resulting in occlusion of the dentinal tubules. Kawe et al did an environmental scanning electron microscopic (ESEM) examination to examine whether KTP, middle power output GaAlAs diode and CO<sub>2</sub> lasers were able to seal dentinal tubules with and without prior application of different types and concentration of fluoride, they demonstrated that diode lasers showed partial occlusion of dentinal tubules.<sup>26</sup> Thus, it was concluded that medium power output GaAlAs diode laser causes both nerve analgesia and partial occlusion of dentinal tubules due to which there is reduction in dentin hypersensitivity levels.

At 12 weeks level of evaluation, the mean reduction in VAS scores though still being significant at 2.65 had worsened from the 48 hours level of evaluation when the last laser application was done which showed that there was recurrence of dentin hypersensitivity in the treatment group. This may be because the laser effects are considered to be due to the combined effect of sealing of dentinal tubules which is long lasting and nerve analgesia which is short lived.<sup>9</sup> At 12 weeks level of evaluation, nerve analgesia effect must have ended thereby resulting in recurrence of dentin hypersensitivity. The reduction of dentin hypersensitivity levels from baseline at 12 weeks level of evaluation can be explained by the photobiomodulating effect. The laser interaction with the dental pulp causes a photobiomodulating effect, increasing the cellular metabolic activity of the odontoblasts and obliterating the dentinal tubules with the intensification of tertiary dentin production.<sup>27</sup>

An important aspect to be considered in the present result is that, although a clinical and statistically significant reduction was observed in dentin hypersensitivity for the treatment

group, a significant reduction was also observed for the control group in the first 48 hours that received application of curing light as a placebo with p-value being significant at all the three levels of evaluation. A strong placebo effect is commonly described in clinical dentin hypersensitivity trials. This effect consists of a complex mixture of physiological and psychological interactions, depending considerably on the doctor-patient relationship, with both parties needing to believe that the treatment is valuable and desiring to obtain relief of symptoms.<sup>11</sup> Investigators have described patients obtaining relief without any treatment due to the placebo effect. This is thought to vary from 20 to 60% in dentin hypersensitivity clinical trials.<sup>9</sup> As the oral prophylaxis of the region was done prior to application of curing light at all the three times of evaluation which might have diminished irritation from the bacterial acids by removal of bacterial biofilm leading to reduced dentin hypersensitivity levels immediately after prophylaxis and subsequent curing light application.

However, the 12-week follow-up shows that the dentin hypersensitivity in control group had worsened than the 0, 24 and 48 hours level of evaluation and the reduction in VAS scores from the baseline was insignificant. An explanation for this may be that, although removing the bacterial biofilm may provide a stimulus for secondary dentin formation, it is not capable of providing any type of analgesia: it only diminishes irritation from the bacterial acids.<sup>28</sup>

## CONCLUSION

Within the limitations of this study, it can be concluded that:

- GaAlAs middle power output diode laser is effective in providing immediate relief in severe cases of dentin hypersensitivity although long-term results show recurrence of dentin hypersensitivity.
- Also, it can be concluded that the laser parameters used in this study, i.e. 810 nm wavelength, at 0.5 W power and for a duration of 2 minutes, were safe and no adverse effects were seen on teeth irradiated with laser.

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