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Dentinal Hypersensitivity Treatment with 1064 nm and 980 nm Diode Laser

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Abstract: Dentinal Hypersensitivity (DH), a prevalent oral health issue affecting approximately one-third of adults. In this six-months retrospective study, a comparison was made for the long-term effectiveness of two diode lasers with wavelengths of 980 nm (Smart M, Lasotronix, Warsaw, Poland) and 1064 nm (Smart M, Lasotronix, Warsaw, Poland) in the treatment of tooth affected by DH. In total, 160 patients were included in this study. Patients were randomly divided into two groups: one receiving treatment a diode laser with a 980 nm wavelength (n=80) while the other group received a treatment with a wavelength of 1064 nm diode laser (n=80). Pain was assessed using the Visual Analogue Scale (VAS) at starting point (T0), directly post-treatment (T1), at 3 months (T3) and 6 months (T6) of follow-up. Both groups followed the same treatment protocol, involving the application of a graphite paste to the exposed dentin before laser irradiation. Lasers operated at an output power of 0.5 W in continuous and non-contact mode, with a 320 μm spot size. A significant reduction in mean VAS scores at all follow-up intervals compared to baseline was noted. 980 nm group had mean VAS scores of 7.9, 2.36, 2.31, and 2.38, while the 1064 nm group had scores of 8.01, 1.01, 1.16, and 1.13 at T0, T1, and at T3 and T6, respectively. At all times of follow-up, the 1064 nm wavelengths revealed a statistically significant reduction in values of VAS compared to the 980 nm. The findings may inform future research on optimizing laser-based treatments for DH.

Keywords: laser dentistry; restorative dentistry; dentinal tubular occlusion; diode laser; dentinal hypersensibility; pain management

1. Introduction

Dentin hypersensitivity (DH) refers to the sensation of brief, intense discomfort experienced when exposed dentin reacts to various stimuli, such as temperature changes, air flow, touch, chemical substances, or osmotic factors. This sensation cannot be linked to any other existing dental issue or pathology [1–3]. The prevailing and widely accepted explanation for dentinal hypersensitivity (DH) is Brännström's hydrodynamic concept. [4]. According to Brännström, mechanical or chemical external stimuli causes fluids to move inside the dentinal tubules, which will stimulate nerves endings thus resulting in a perception of pain by the patients [4]. Based on available literature, almost one-third of adults' experience DH, whose causes are multifaceted, involving factors like abrasion, acid erosion, and stress-related dental issues [5,6].

A large number of treatments were suggested for the management of DH. One of the most accepted and documented protocols aim to shield or seal the dentinal tubules to reduce nerve stimulation [7–11]. For this purpose, several desensitizing substances, such as potassium ions, arginine, and calcium carbonate, have been developed [7–11]. Comparative studies indicate varying levels of effectiveness for these agents, depending on the type of stimuli [11]. However, achieving long-lasting relief remains challenging.

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In the aim of obliterating dentinal tubules, high power lasers have gained attention in the management of DH due primary to its possible safe and effective melting of dentinal tubules [12,13]. In this context, specific protocols involving lasers with wavelengths such as 980 nm and 1064 nm have demonstrated effectiveness [12–17]. In fact, high-power lasers can melt the dentin surface to block fluid movement in the tubules. For example, a protocol involving the use of graphite paste combined with laser irradiation has garnered attention recently, demonstrating both safety and promising outcomes [13,14]. Another well-documented approach for managing DH involves modulating the nervous response through the use of agents capable of inhibiting or reducing neuronal transmission. Nanohydroxyapatite has garnered considerable attention for this purpose due to its biocompatible nature and inorganic bone structure, featuring crystals ranging in size from 50 to 1000 nm. This unique property of nanohydroxyapatite enables it to effectively fill small gaps and depressions on the enamel surface, potentially surpassing the efficacy of fluorides in DH management [11]. In an in-vitro study, Sahin et al. [11] demonstrated that both Er: YAG laser and nanohydroxyapatite applications lead to significant DH obliteration; however, laser treatment with Erbium results in smoother surfaces, possibly aiding in the prevention of dental plaque accumulation [11]. Additionally, various in-home methods have been explored in the literature for DH management, offering supplementary or standalone treatment options based on the severity of the condition [8]. A systematic review and meta-analysis (SR-MT) have indicated that the twice-daily application of dentifrice formulations containing stannous, potassium, or arginine may be recommended for DH reduction [8]. As for the use of lasers, a SR-MT by Pion et al. [X], concluded based on 34 clinical trials and found that lasers, whether using high-power or low-power lasers, effectively reduced pain associated with DH after three months of treatment. However, there was no statistically significant difference between the two lasers types. The study concluded that laser therapy is a viable option for DH control but highlighted the need for a standardized treatment protocol due to variations in evaluation methods among studied [X]. Nevertheless, it is worth noting that a standardized methodology guideline for DH management is currently lacking.

Given this context, our clinical investigation aims to evaluate and compare the efficacy of a treatment protocol involving the use of a 980 nm diode laser (Smart M, Lasotronix, Warsaw, Poland) with that of a 1064 nm diode laser (Smart M, Lasotronix, Warsaw, Poland) over a six-month follow-up period in terms of pain reduction in DH tooth. To the best of our knowledge, this is the inaugural study to assess the effectiveness of a 1064 nm diode laser and juxtapose it with the results obtained using the 980 nm wavelength. The study's null hypothesis posits that there is no statistically significant disparity in treatment outcomes between the two laser wavelengths (980 nm and 1064 nm) over the specified timeframe.

2. Materials and Methods

2.1. Study Design

The clinical study involved a total of 160 patients, each having a discomfort of DH in a single tooth. Within this, precisely eighty individuals (n = 80) underwent DH treatment employing a 980 nm diode laser (Smart M, Lasotronix, Warsaw, Poland), while the remaining 80 patients (n = 80) received therapeutic intervention utilizing a 1064 nm diode laser (Smart M, Lasotronix, Warsaw, Poland). The meticulous conduct of the study is aligned with ethical guidelines, following the Declaration of Helsinki. This study received the approval from the Ethics Committee, complete with authorization code CUMEB/D156/302018, which was officially conferred on September 24, 2018. Prior to the DH treatment, all patients exhibited their unwavering commitment to the study by providing explicit, written informed consent. The decision to proceed with DH treatment was made after the signature of the written informed consent and potential side effects, and any conceivable complications were comprehensively elucidated.

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2.2. Inclusion and Exclusion Criteria

Inclusion criteria encompassed patients with a solitary permanent tooth diagnosed solely with dentinal hypersensitivity (without the presence of any other dental defects), and who actively sought treatment.

2.2.2. Exclusion Criteria

Excluded from the study were patients with teeth displaying any additional pathology or defects, such as irreversible pulpitis or necrosis, carious lesions, compromised restorations, signs of attrition facets, premature contacts, or cracked enamel. Additionally, patients currently using analgesic, anti-inflammatory medications, sedatives, tranquilizers, anticonvulsants, or any other medications that could potentially alter pain perception were also excluded.

2.3. Randomization

A randomization technique was applied to distribute participants into two separate cohorts. Microsoft Excel (Microsoft office), a commonly used data management tool, was employed for the randomization process. A roster containing all qualified participants was established, and each individual was given a unique code. Using Excel's random number generator feature, random numbers were generated for each participant. These numbers were then organized in ascending order. The first segment of this sorted list was assigned to the group 980 nm diode laser treatment for DH (group A), while the latter segment was designated to receive a treatment with the 1064 nm (group B). This methodology ensured an equal likelihood of any participant being included in either group, thereby reducing the chances of selection bias and reinforcing the study's credibility. The use of Microsoft Excel for this randomization made the procedure both effective and transparent, contributing to a rigorous and trustworthy examination of the research question.

2.4. Pain Assessment and Follow-up

Pain assessment and follow-up were integral components of this study, with the objective of evaluating the efficacy of the treatment on DH. The visual analogue scale (VAS) served as the primary tool for quantifying pain levels experienced by the participants. On this VAS, a score of zero signified the absence of any pain, while a score of ten signified the most intense pain imaginable. A total of 160 patients were included in the study, and they were requested to rate their pain levels at specific time points: before the initiation of treatment (T0), immediately after treatment (T1), and during two subsequent follow-up periods at 3 months (T3) and 6 months (T6). To ensure a standardized and consistent evaluation process, all patients underwent a methodology inspired by the Schiff cold air scoring system. This assessment involved the application of a controlled burst of cold air with a pressure range of 4 to 4.5 from a dental syringe equipped with a tri-functional tip. The stream of air was directed perpendicularly at the affected tooth region, maintaining a distance of approximately 1 cm, and lasted for precisely one second. During this procedure, a gloved finger was judiciously employed to protect the neighboring teeth from exposure to the cold air stimulus. This rigorous pain assessment protocol was meticulously executed to enable precise and reliable tracking of pain reduction and treatment outcomes over time. This adopted standardized pain assessment technique, increased the accuracy of the comparisons between pre-treatment and follow-up pain scores.

2.5. Treatment protocol and irradiation parameters

Both treatment protocols involving the 980 nm diode laser (group A, n=80) and the 1064 nm diode laser (group B, n=80) followed identical procedures and irradiation parameters. Group A utilized a 980 nm diode laser (Smart M, Lasotronix, Warsaw, Poland), while Group B employed a 1064 nm diode laser from the same manufacturer. Before irradiation, a paste resembling yogurt in consistency was created by mixing graphite powder (Pressol graphite, Nurnberg, Germany) with distilled water. This graphite paste was then applied to cover the surface of the exposed dentin for the intended tooth to be treated. The graphite paste was applied on the concerned area using a micro

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brush. After that, all excessive graphite paste was carefully removed. Subsequently, the laser was prepared, the patient, assistant and operator wore specific protective glasses for each of the wavelengths (980 nm diode laser for Group A and 1064 nm diode laser for Group B). The laser irradiation parameters were as following: an output power of 0.5 W in continuous non-contact mode, with a spot size of 320 μm. The irradiation rate was approximately one mm per second in non-contact mode, and the laser beam was directed tangentially (at ±45°) to the dentin surface, maintaining a 1 to 2 mm distance between the optical fiber and the treated area. The irradiation process ceased when visual evidence of paste vaporization was observed. Side effects were noted and after a wait of almost thirty seconds, the patient was invited to assess his pain as it was described in section 2.4.

2.6. Statistical Analysis

Data analysis was carried out with Prism 5 software by GraphPad Software (GraphPad, San Diego, California, USA). Statistical significance was determined by a p-value less than 0.05.A confidence level set at 99%, with a p-value less than 0.001, was viewed as highly consequential. Basic statistical measures, such as the average and standard deviation for VAS scores, were determined for each patient group at various time intervals: before treatment (T0), immediately following treatment (T1), three-months (T3), and six-months after treatment (T6). Moreover, the normal distribution of all values in each group was assessed using the normality tests D'Agostino & Pearson, Anderson-Darling, Shapiro-Wilk, and Kolmogorov-Smirnov tests for normal distribution. For comparison between the two groups (group A and group B) at each time interval (T0, T1, T3, T6), an independent Student's t-test was used. Any statistically significant differences between the groups were highlighted by a p-value less than 0.05.

3. Results

3.1. Group A (980 nm diode laser; n=80)

Within Group A, where the 980 nm diode laser was employed, a statistically significant reduction in mean Visual Analogue Scale (VAS) scores was consistently observed at all follow-up time points (T1, T3, T6) compared to the baseline measurement at T0. This reduction in VAS scores indicates the efficacy of 980 nm diode laser treatment in the management of DH. At T0, the mean VAS score was at a mean of 7.9, indicating a significant level of discomfort experienced by the patients. However, immediately after treatment (T1), the VAS score decreased to a mean value of 2.36, signifying an immediate and significant decrease in pain. This reduction persisted at T3 (mean value of 2.31) and was maintained even at the 6-month follow-up (T6), where the mean VAS score remained at 2.38. These findings suggest that the treatment was initially effective and that the treatment was able to provide a stable relief over an extended period of 6 months.

3.2. Group B (1064 nm diode laser; n=80)

In Group B, where the 1064 nm diode laser was used, a similarly significant reduction in mean VAS scores was observed at all follow-up intervals (T1, T3, T6) in comparison to the baseline measurement at T0. This demonstrates the efficacy of the 1064 nm diode laser in managing dentin hypersensitivity. At the T0, Group B had a mean VAS score of 8.01, signifying substantial pain and discomfort. Post-treatment (T1), this score dramatically decreased to 1.01, highlighting the rapid and effective relief offered by the 1064 nm diode laser. This reduction persisted at T3 (mean value of 1.16) and was sustained at T6 (mean value of 1.13), indicating a six months stability of the treatment made.

3.3. Comparison between Group A and Group B

The comparative analysis between Group A (980 nm diode laser) and Group B (1064 nm diode laser) reveals noteworthy distinctions in mean VAS score values, both immediately after treatment and at the six-month follow-up. At T1, Group B exhibited a substantial reduction in mean VAS score (1.01), surpassing that of Group B (2.36). This suggests that Group B patients experienced a more

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rapid initial response to treatment, possibly attributable to the specific characteristics of the 1064 nm diode laser. Furthermore, at the six-month follow-up (T6), Group B (1064 nm) maintained a statistically lower mean VAS score (1.13) compared to Group A (980 nm), where the mean VAS score was 2.38. This finding implies that Group B continued to benefit from the treatment, experiencing sustained relief from dentin hypersensitivity over the long term.

In light of these results, the null hypothesis, positing no significant difference in the treatment outcomes between the two laser wavelengths, was confidently rejected. The data underscores that the choice of diode laser wavelength plays a role in the efficacy and durability of dentin hypersensitivity treatment.

		Baseline (T0)	Immediately after (T1)	T3	T6
Group A	Mean	7.9^{A}	2.36^{B}	2.31^{B}	$2.38B^{B}$
Diode (980 nm) (*n=80*)	Std.	0.321	0.692	0.517	0.532
Group B	Mean	8.01^{A}	1.01^{C}	1.16^{C}	1.13^{C}
Diode (1064 nm) (*n=80*)	Std.	0.220	0.453	0.732	0.512

Different superscript letters indicate statistically significant difference ($^{A, B}$); similar superscript letters indicate the absence of a statistically significant difference ($^{A; A}$). mean = mean value; std. = standard deviation. T0= before treatment; T1= immediately after; T3= 3 months after; T6= 6 months after.

4. Discussion

The present retrospective study has unveiled successful dentin hypersensitivity (DH) treatment outcomes in a cohort comprising one hundred and sixty patients, equally divided between those subjected to a 980 nm diode laser and those exposed to a 1064 nm diode laser. This finding suggests that laser-assisted DH treatments, as conducted within the outlined protocol, yield favorable results that endure for up to six months. As articulated in the introduction, the central objective of this clinical investigation was to gauge the efficacy of DH management by inducing the direct fusion or obliteration of exposed dentinal tubules through laser irradiation. This action, rooted in Brännström's hydrodynamic theory, acts as a barrier against external stimuli. Based on the study's findings, both laser wavelengths within the designated protocol demonstrated a significant reduction in pain, which remained consistent throughout the six-month follow-up period. Notably, a significant discrepancy in pain reduction in favor of the 1064 nm diode laser was observed, prompting the conclusion that the 1064 nm wavelength appears to be more effective than the 980 nm wavelength.

The obliteration of exposed dentin can be attributed to the laser-tissue interactions specific to the 1064 nm and 980 nm diode laser wavelengths [18–20]. For instance, Namour et al. [14] reported in an in vitro study that the 1064 nm wavelength possesses properties conducive to fusing and melting exposed dentin in a single application [14]. This observation was corroborated through scanning electron microscopy conducted on extracted molars [14]. Moreover, the protocol employed in this study closely paralleled Namour et al.'s approach, which involved the application of graphite paste to coat the exposed dentin [14]. Both the 980 nm and 1064 nm wavelengths exhibit strong absorption by pigmented matter (dark matter) [21]. Consequently, when the same amount of energy is delivered, applying graphite paste for surface coating enhances tubule obliteration compared to a non-coated surface [14,21]. Laser irradiation generates elevated temperatures at the exposed dentin, leading to immediate dentinal fusion and, in turn, partial or complete tubule obliteration [14,21]. An additional rationale for using graphite paste is its capacity to limit energy absorption to superficial layers, preventing a rise in temperature at the pulpal level [22,23]. This feature was also demonstrated in a study by Namour et al. [14].

It is noteworthy that our study showcased statistically significant improvements in mean VAS scores immediately after treatment and up to six months in favor of the 1064 nm wavelength. This

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can be attributed to the fact that the 1064 nm wavelength is more efficiently absorbed by pigmentation compared to the 980 nm wavelength. When photons from the 1064 nm diode laser interact with dark pigmentation, such as graphite in this case, the energy of the photons is more intensively absorbed by the pigmentation. Consequently, this generates greater localized heat and, in turn, enhanced dentinal fusion and tubule obliteration [14]. The management of dentinal hypersensitivity has consistently been a focal point of scientific inquiry in the field of dentistry [24–28]. Another laser-based approach for DH management is photobiomodulation therapy (PBM) [29]. PBM leverages the therapeutic application of light to modulate non-thermal responses in living tissues [29–35]. In cases of dentinal hypersensitivity, PBM appears to operate by altering cellular reactions, resulting in reduced pain. This occurs partly due to nerve fiber depolarization and partly due to the formation of tertiary dentin [35]. A retrospective study by Namour et al., encompassing three distinct DH management methods - PBM therapy employing a 660 nm red light laser, Nd: YAG laser at 1064 nm, and Nd: YAP laser at 1340 nm - revealed that the PBM group reported complete pain elimination (mean VAS score of 0). In contrast, the Nd: YAG and Nd: YAP groups recorded mean VAS scores of 1.065 ± 0.674 and 4.665 ± 0.674, respectively. The results obtained with the Nd: YAG laser align with our findings involving the 1064 nm laser, suggesting that regardless of laser type, it is the wavelength that fundamentally influences interaction with dentinal tubules. Additionally, a systematic review by AlHabdan et al. [36] proposed that using the Er, Cr:YSSG laser can effectively alleviate DH with minimal side effects when appropriate settings are applied [36]. However, consensus on the definitive efficacy of lasers for DH management remains elusive. A meta-analysis examining the comparative efficacy of various topical desensitizers versus lasers found insufficient evidence to conclusively establish the superiority of lasers over desensitizing agents [37]. Moreover, a study by Butera and colleagues [38] indicated that toothpaste containing hydroxyapatite may be a viable option for at-home DH treatment due to its superior capacity to alleviate hypersensitivity compared to traditional fluoride toothpaste [38]. Within the scope of this study, which included a relatively short-term follow-up period of three months, both the 980 nm and 1064 nm diode lasers exhibited promise as effective approaches for managing dentin hypersensitivity when following our specified protocol. Nonetheless, the study highlights the need for further research to elucidate the influence of factors such as age, race, gender, psychological aspects of patients, and the etiological treatment of DH, including factors such as high consumption of acidic products and other contributors to DH.

5. Conclusions

Based on this retrospective study and within its limitations, it can be suggested that the use of laser-assisted protocol described in this study with a 980 nm and 1064 nm diode laser results in a successful management of pain arising from dentinal hypersensitivity and within a six months follow-up. The 1064 nm diode laser resulted in a significant reduction in pain due to DH compared to the 980 nm.

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