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The effect of 980 nanometer diode laser in relieving dentin hypersensitivity: a clinical study

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Abstract

Dentin hypersensitivity is a common issue happened due to exposure of the root surface. Patients with dentin hypersensitivity complain from sharp short pain that triggered by different stimuli, such as thermal changes, tactile stimuli and osmotic changes. This study aims to explore the effect of the 980 nanometer diode laser in treatment of the dental pain associated with dentin hypersensitivity over 4 weeks period. Ten patients with exposed root surfaces suffering from dentin hypersensitivity were subjected to treatment by using 980 nanometer diode laser, three treatment sessions for each patient. The pain severity evaluated before and after treatment.8 of the 10 patients participated in the study felt relived after three sessions of treatment. Only two patients still feeling a little discomfort for thermal changes. According to the result of this study, the diode laser (980 nanometer) has a very good effect in relieving the discomfort of the dentin hypersensitivity.

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Introduction

Dentin hypersensitivity is a common clinical condition that is characterized by sharp pain arising from exposed dentin in response to various stimuli.the exposure of open dentinal tubules causes the transmission of the dentinal fluid with the change in stimuli pressure. It also can be defined as "a 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 disease (El Mobadder *et al.* 2023).

Patients with Dentin hypersensitivity (DH) often report discomfort when consuming hot, cold, sweet, or acidic food and beverages. Moreover, simple everyday activities such as tooth brushing and even breathing in cold air through the mouth can provoke the pain associated with DH. Sensitive teeth most frequently result when the teeth lose their enamel protection or the gums recede, leaving the sensitive dentin layer exposed (Fig.1). As a result, DH can have a significant negative impact on the quality of life and the oral health of the patients. For instant pain relief, over-the-counter desensitizing toothpastes or mouthwashes are often recommended by oral health professionals. However, the efficacy of these products in managing DH in the long term is still under debate (Irwin *et al.* 1997). This debate based on practical and clinical experiences that showed clearly gradual disappearance of the effect of these materials after several months. Theses materials will be wiped off by thewashing effect of saliva, the mechanical effect of mastication and the chemical nature of food (Davari *et al.* 2013).

Many different causal agents, ranging from simply inhaling cold air to potentially serious underlying pathological conditions, can prompt symptoms of dentin hypersensitivity. This includes dietary erosion, bruxism, use of abrasive toothpaste, acidic mouthwash, harsh brushing, gingival recession due to periodontal disease, erosion by gastro-esophageal acids, and intrinsic methamphetamine abuse (Gillam *et al.* 2019).

From a literature review, it is generally agreed that treatment should firstly begin with the exclusion of plaque, calculus, and other periodontal-related disorders through proper differential diagnosis. Various clinical approaches including the application of oxalates, glutaraldehyde, resins, or dentine bonding agents are used to manage DH.These treatments aim to either physically occlude the patent dentinal tubules or prevent the neural transmission. Localized pain control through the application of lasers has been suggested as a new approach in managing DH more effectively. Different types of lasers including the low power diode, pulsed Nd:YAG, CO_2, and Er: YAG lasers have been used in the clinical treatment of DH. The 980nm diode lasers is now designed to be the treatment of choice for clinical applications such as soft tissue surgery in periodontology and the relief of dentin hypersensitivity(Borges 2021). The wavelength that is output by a diode laser is a key determinant of the photo-biological reaction being sought in both the soft and hard tissue. The continuous mode diode laser operation provides uniform delivery of energy to the hard tissue. This will provide the opportunity for the effectiveness of the desensitizing result (Borges *et al.* 2021, Khoroushi *et al.* 2019).

First-generation lasers such as the Argon laser, Nd-YAG laser, and CO_2 laser utilized thermal effects for the desensitization process, which could cause collateral damage to the cementum due to the existence of patent dentinal tubules in root surfaces. The newer lasers designed for desensitization, such as the 980 nm diode laser, do not rely on non-specific thermal effects. Instead, they use photonic energy to modify nerve function and produce a lasting effect on pain to eliminate the nerve response. The authors believe that, with the appropriate laser settings, the energy is absorbed by intratubular fluid, and it is this fluid in the dentinal tubules that is thought to mediate dentinal hypersensitivity (Qadri *et al.* 2005).

There are many studies used 980 nm diode laser as a treatment option in many countries over the world in different population. In Iraq, there is very little

studies about this subject (especially in southern area). The objective of this clinical study is to investigate the efficacy of 980 nm diode laser in relieving DH over a period of 4weeks.

The data was collected through a meticulous process. Subjects were tested using a compressed air source that was set to 80 psi (pounds per square inch) to deliver cold air at ambient temperature. A triple syringe (already attached to the dental chair) was used as a nozzle to direct the air onto the subject's teeth. The subjects received ten seconds of cold air stimulation. After stimulation, the subjects were asked to indicate the level of discomfort experienced and were given a score ranging from "no pain" to "unbearable." The scale was categorized into four levels; score 0 was defined as "no pain," score 1 was defined as "mild pain," score 2 was defined as "moderate pain," and score 3 was defined as "severe pain." If cold air stimulation results in a score less than 2, the subject would qualify to be a part of the study as he/she had to be experiencing dentin hypersensitivity condition. The qualified subjects attend treatments using 980 nm diode laser. During the treatment, the parameters and settings proposed by the laser manufacturer were used. The parameter settings were programmed onto the laser control unit and the treatment was started after the hand piece was being properly placed. All the enamel/dentine hypersensitivity parameters collected in this clinical study will be processed and analyzed using statistical software. By comparing the mean change of each parameter before and after the laser treatment, the effectiveness and efficiency of diode laser in treating dentin hypersensitivity can be identified. It is hoped that at the end of this clinical study, an objective assessment on the clinical value of 980 nm diode laser in treating dentin hypersensitivity can be provided.

Materials and methods

Study design

In this study, the 980 nanometer diode laser is used in relieving dentin hypersensitivity. A randomized control trial design is used in this study. The main objective of a randomized control trial is to compare the efficacy of a new treatment to a standard treatment or to a placebo. By randomizing the test subjects to different treatment groups, the effect of all possible variables is minimized. Blinding, meaning that the patient does not know what treatment he or she is getting and the examiner who is recording the result does not know what treatment the patient has been given, is employed. In doing so, it will eliminate the possibility of psychological bias from the patient and the examiner. For the patients' side, they are only required to provide the necessary information and undergo the treatment. As for the clinicians, which is our research team, other than the treatment protocol, they do not have access to the treatment record. They will also record the pain before and after any procedure, whether a placebo is being used or not, so as to give a true comparison of the pain relief obtained from the treatment process. This design will help to minimize the risk of bias and it will give a precise and absolute conclusion at the end of the study.

Patient selection

10 patients (7 males and 3 females) in between the age range of 18 – 50 years. All patients were reported with a history of dentin hypersensitivity, and all of them have at least one tooth with dentin hypersensitivity confirmed by the air blast test. The teeth should be vital and without any cracks or restorations. Exclusion criteria included patients with periodontal disease; patients who had received periodontal treatment or scaling and root planning in the last 6 months; pregnant or nursing mothers; patients who had used an occluding dentifrice, mouth rinse, or who had received professional tooth cleaning or desensitizing treatment in the last 30 days; patients who have medical conditions which would contraindicate elective dental procedures; patients having taken antibiotics in the last 3 months; patients who have had any oral surgery in the last 6 months; and patients who have allergic to any medication used.Also, the patients with any systemic disease or immune deficiencies were excluded from the study The study was performed at the clinics of National

University of Science and Technology, Dhi-Qar, Iraq. The treatment done in the period from November 2023 to March 2024.

Sample size calculation

A minimum clinically significant difference in visual analogue scale scores of 0.6 was used in this study (taken from another research about DH (Yates *et al.* 2004). The power analysis was performed depending on this minimum clinically significant difference in visual analogue scores, using Alpha level(α) = 0.2, at 80% power, and effect size(σ) of 1.12. According to these parameters, the number of patients needed to be participated in this study was 10.

Working method

The exposed root surface was dried out from the saliva and irradiated by the laser beam (unfocused mode) in semi-circular motion for two minutes, with avoiding direct contact with the gingival margin. A special bio stimulation tip has been used (see Fig.3). The tip held perpendicular to the root surface. Each patient received three sessions of treatment, with 2-3 days separation between sessions. All the patients were checked 4 weeks after laser therapy.

laser device technical specifications:H1 laser device from Pioon Technology, 980 nm wavelength laser beam delivered by 400um diameter optical fiber. The device generates a maximum of 10 W power that can be used in pulsed or continuous mode.

Laser beam parameters

The laser has been used in pulse mode with 1 millisecond pulse duration, 500 Hertz frequency. The peak power was 2 Watts, average power used was 1 Watt (see Fig.2)

Statistical analysis

The Statistical Package for Social Sciences (SPSS) version 20.0 was used for data analysis. The significance level was set at 5%, with a confidence interval of 95%. The findings were presented in bar graphs, pie charts, and in the text to facilitate understanding of the analysis.

Results

The application of 980 nanometer diode laser reduced the dentin hypersensitivity, and the level of tactile and air blast hypersensitivity decreased remarkably in 3 days, confirming that diode laser is an effective treatment for dentin hypersensitivity. 8 of the patients participated in this study felt better after completing 3 sessions of treatment, and two of them still have pain on air-blast test. After 30 days, all the 8 patients reported no discomfort or hypersensitivity (Fig.4).

Fig. 1. Exposed root surface of the lower canine with denuded dentinal tubules.

The significance level was established in the analysis at $p < 0.05$. This gives an indication that the laser treatment on dentin hypersensitivity lowers the pain sensation compared to the regular toothpaste used in the market for the relief of dentin hypersensitivity.

Fig.2. Laser beam parameters used in treatment protocol.

Discussion

The application of 980 nanometer diode laser is an effective treatment for dentin hypersensitivity. This can be explained by the fact that the 980 nanometer diode laser can penetrate into the oral tissue and initiate the photobiostimulation effect, inducing a secondary physiologic response and neural inhibition to inhibit hypersensitivity. Also, Laser treatment would cause the tubules to be partially obliterated or closed off, thereby reducing the fluid flow within the dentinal tubules that lead to the pain response (Fekrazd *et al*. 2009).

Fig.3. Special biostimulation tip.

For further explanation, recent studies have suggested three main explanations about how laser work on dentin surface to decrease hypersensitivity. The first mechanism is the thermal effect of laser on the dental tissues that will lead to denaturation of organic content and melting of inorganic content on dentin surface, and hence, sealing and dentin tubules. The second mechanism thought to be the heat

generated by irradiation that will reduce the fluid movement in the dentinal tubules (hydrodynamic theory), leading to reduction of the sensitivity of the dentin. The third mechanism based on the photobiostimulation effect of the laser, which stimulate the odontoblast form extra layers of dentin and narrowing the diameter of the dentinal tubule (Hashim *et al.* 2023). Pourshahidi, S.*et al* 2019. Compare between the efficiency of erbium laser 2780 nm and diode 980 nm in relieving the DH pain and he found that both lasers are effective in decreasing the pain with better effect of the erbium laser after 30 days of treatment (Pourshahidi *et al.* 2019). This result coincides with the findings of this study.

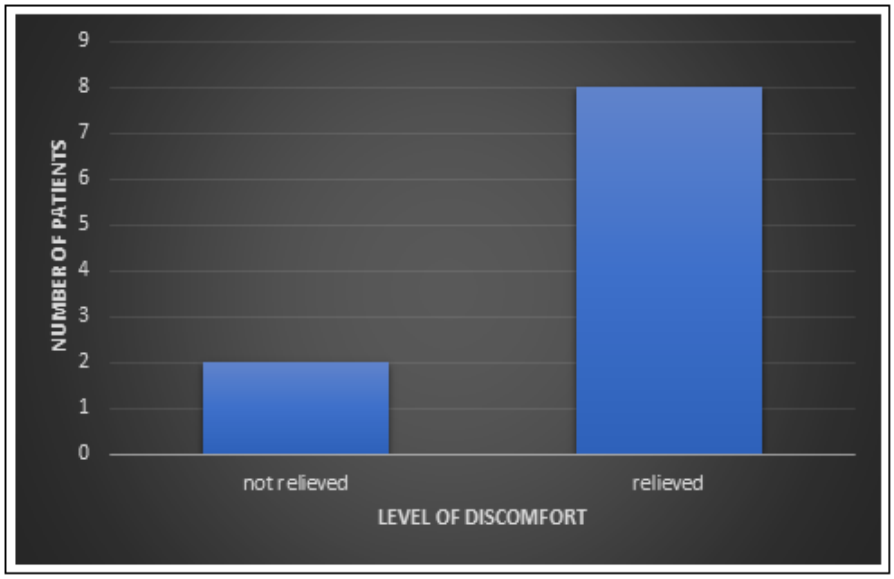

Fig. 4. Bargraph represents the number of patients who felt better\ still have discomfort after 30 days of laser treatment.

Another study, done by Tanwar *et al.* in 2022, tried to alleviate dentin hypersensitivity by using 980 nm diode laser and sodium fluoride. they noticed the morphological alterations in dentin surface. they found that "The 980 nm diode laser presents a promising new potential for treating dentin hypersensitivity, both alone and in conjunction with desensitizing agents (Tanwar *et al.* 2022)."the findings agreed well with this study.

There is no study that oppose or disagree with laser effect on dentin hypersensitivity. There is some dispute or controversy about thelong-term effect of laser irradiation on dentin hypersensitivity. Some studies suggest diode laser irradiation with parameters designed for desensitizing does not affect the surface of enamel or dentine morphologically, but small fraction of the laser energy may be transmitted through dental hard tissues to reach the pulp causing inflammatory response in the pulp and increasing the pain (Kimura *et al.* 2000). Also, many researchers debate about how costly is the laser treatment, when compared to other materials (such as bonding agents, desensitizing agents, varnishes, etc.). The laser devices and equipment are more expensive than varnishes and desensitizing agents and require a special training to be used properly which make them more costly in treatment.

Conclusion

In summary, the use of the 980 nm diode laser was associated with significant reduction in dentin hypersensitivity. From a clinical perspective, this research provides useful evidence on the efficacy of 980 nanometer diode laser in treating dentin hypersensitivity. It also lends support to the application of such intervention in dental practices. The laser treatment also guarantees quick relief, which provide a more efficient and effective alternative to other forms of treatments and help to

improve patient satisfaction.

Recommendation for future work

Future research could explore several avenues to enhance our understanding and treatment of dentin hypersensitivity. One avenue involves comparing the effectiveness of a 980nm diode laser with potassium-based desensitizing toothpaste, shedding light on which treatment modality offers superior relief. Additionally, expanding studies to include more diverse patient groups and larger sample sizes would bolster the epidemiological significance of findings, providing broader insights into the efficacy of 980nm diode laser therapy across different demographics. Furthermore, comprehensive comparisons between diode lasers and traditional methods, such as fluoride varnishes or dental sealants, could elucidate the advantages and potential drawbacks of laser treatments in managing dentin hypersensitivity. Such research could inform clinicians on optimizing therapeutic approaches and improving patient outcomes in dental practice.

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Ethics approval and consent to participate

This study was conducted in the National University of Science and Technology, Dhi-Qar, Iraq,between November 2023 and March 2024. All subjectsparticipated voluntarily in this study and received asmall compensation. The study was approved by the College of Dentistry, National University of Science and Technology, Dhi-Qar, Iraq, By the university order No.124.

Data availability

The authors confirm that the data supporting thefinding of this study are available within the article.

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Authors' contributions

Both authors contributed equally to the design and implementation of the research, to the practical work, to the analysis of the results, and to the writing of the manuscript.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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