Dentin hypersensitivity treatment with Nd:YAG laser: A systematic review

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Abstract

Objective: To compare the efficacy of Nd:YAG laser to other chemical agents in the treatment of dentin hypersensitivity.

Material and Methods: PubMed, EbscoHost, ProQuest, and Google Scholar were searched for articles published between 2012 to 2022 in English, reporting randomized clinical trials, completed and with results. This systematic review was performed following the Preferred Reporting Items for Systematic Reviews (PRISMA) guidelines, and a critical appraisal of the literature was assessed by using JBI’s Checklist for Randomized Controlled Trials.

Results: From 536 articles found in the search based on keywords, 354 were filtered based on study design and desired period range, and six randomized clinical trials were eligible for the systematic review, reporting patients from 18 to 65 years old, with clinical diagnosis of dentin hypersensitive, that evaluate the efficacy of Nd:YAG laser, compared to pre-treatment using visual analog scale, yelepe probe scale, verbal rating scale and laser doppler flowmetry (LDF). These studies evaluated 159 patients and at least 402 hypersensitive teeth. Follow-up periods were considered from immediate to six months post-treatment. All active ingredients and laser treatment effectively reduce dentin hypersensitive and can maintain its efficacy over time. Only one study suggested treatment with Nd:YAG laser is not significant compared to Er,Cr:YSGG laser.

Conclusion: Nd:YAG presents a significant immediate reduction of dentin hypersensitive and shows promising results in the long time effects. More standardized evaluation protocols should be implement-ed to increase the robustness of the results.

Keywords: Dentin desensitizing agent, Dentin hypersensitive, Dentin hypersensitivity treatment, Nd:YAG, Laser, Tooth sensitivity

Introduction

Dentin hypersensitivity is one of the most common patient complaints and has a characteristic pain response to chemical, thermal, tactile, evaporative, or osmotic stimuli. The cause of fluid movement in the exposed dentinal tubules, causing acute and short-term pain. Developments in science and technology over the last few decades have provided many treatment options for dentin hypersensitivity, ranging from the application of nerve impulse transmission barrier agents such as potassium nitrate to agents that seal the dentinal tubules such as fluoride, oxalate, varnish, adhesive resin, bioglass, to the use of lasers.

Light Amplification by the Stimulated Emission of Radiation (LASER) is a powerful light source that has been widely used in various fields of medicine, including dentistry. Lasers applied to soft tissues can assist in wound healing, removal of hyperplastic tissue, photodynamic therapy, and photostimulation. Lasers applied to hard tissue can be used to remove carious tissue or restorative materials, bleaching, and treat dentin hypersensitivity. The use of lasers in treating dentin hypersensitivity was first introduced in 1985. Lasers that are commonly used to treat dentin hypersensitivity are low power lasers (LPL) like helium-neonium (He-Ne) or aluminum gallium arsenide (AsGaAl), and high power lasers (HPL) like neodymium yttrium aluminum garnet (Nd:YAG) and carbon dioxide (CO2) laser.

High power lasers such as Nd:YAG could cause an increase in temperature on the dentinal surface, which will lead to the closure of the dentinal tubules. Laser technology in the treatment of dentin hypersensitivity generally does not cause side effects or damage to the pulp, but several studies stated that the effectiveness of lasers in reducing dentin hypersensitivity is still unclear. Some researchers have also found that the Nd:YAG laser or other laser protocols have the potential to penetrate through the enamel and dentin to the pulp causing pulpsitis or thermal necrosis of the tooth and also reducing the microhardness of the root dentin.

Although lasers are known to have many advantages, there are still many clinicians who do not use this technology due to a lack of knowledge of lasers in the medical field, do not understand how lasers interact with tissues, their therapeutic benefits, and how to use them according to each clinical condition, which causes dentist cannot provide the best and optimal treatment. This study aims to carry out a systematic review of literatures and compare research results to answer the problem, intervention, comparison, and outcome (PICO) with the question: “Is the Nd:YAG laser effective as an option for dentin hypersensitivity treatment?”.

Methods

This systematic review was conducted following the Preferred Reporting Items for Systematic Review (PRISMA) guidelines. The PICO scheme consists of...
studies in a language other than English.

Data Extraction
Studies that met the inclusion criteria were processed for data extraction. The data recorded were as follows: first author and year of publication, type of treatment, number of teeth, number of subjects, age range, gender, comparison of treatment outcomes between baseline and follow-up. In studies reporting drop-outs, the final number of patients analyzed is recorded. The difference in pain and percentage reduction in dentin hypersensitivity recorded from each study was extracted. Follow-up results were also recorded for each time performed. There are variations in follow-up time from 1 day, 2 to 7 days, 7 days to 1 month, 1 month to 3 months, 3 months to 6 months, and more than 6 months.

Quality Assessment
Quality assessment of the methodology carried out in each study is important for understanding the results of the study. The quality of each study was assessed using JBI’s Checklist for Randomized Controlled Trials. Aspects evaluated were the protocol of randomization and allocation of subjects, whether participants and examiners were blinded to the intervention, how subjects were treated during treatment, follow-up procedures, methods of outcome measurement, and statistical analysis used.

Result
Study characteristics
A total of 5536 articles were found when searching using keywords, 354 articles were obtained after being filtered based on the study design and the desired period. Furthermore, 346 articles were excluded based on irrelevant titles and abstracts, and 2 were excluded because full text was not found, resulting in 6 articles being included in this literature review. PRISMA flow diagram of study selection is shown in Figure 1. All studies that met the inclusion criteria were randomized clinical trials. There was variation in the number of study samples, ranging from 33 to more than 120 teeth. All studies had more than one follow-up period, but most studies performed short-term (up to 1 day) and medium-term (2-7 days, up to 30 days), while long-term evaluation (up to 6 months) has only been performed in a few studies.

In this systematic review, studies that met the following inclusion criteria were selected: (a) randomized clinical trials (RCTs); (b) Full paper studies with results published in the last 10 years; (c) subjects with clinical diagnosis of dentin hypersensitivity; (d) assessment of the effectiveness of the Nd:YAG laser, which reported a reduction in dentin hypersensitivity pain when compared with the pre-treatment; (e) adult subjects over 18 years. If the study had more than one follow-up, all results were recorded.

The exclusion criteria were as follows: (a) in situ study; (b) post-surgery cases; (c) cases after bleaching or periodontal treatment; (d) cases post-restoration or involving tooth preparation; (e) non-randomized clinical studies; (f) case reports; (g) review articles; (h)
### Table 1. Characteristics of included literature

<table>
<thead>
<tr>
<th>Author, year</th>
<th>Number of samples</th>
<th>Age</th>
<th>Intervention</th>
<th>Control Group</th>
<th>Follow up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abed AM et al, 2012</td>
<td>20 patients: 13 women and 7 men (at least 6 hypersensitive teeth)</td>
<td>20-55</td>
<td>Group 1: Laser Nd:YAG laser (10 Hz, 1W, 60S/cm², two times) Group 2: Sensikin® gel</td>
<td>Yes</td>
<td>Before treatment, immediately after treatment, 1 week, 1 month, 3 months, and 6 months after treatment.</td>
</tr>
<tr>
<td>Lopes AO et al, 2013</td>
<td>24 patients (33 hypersensitive teeth)</td>
<td>Not reported</td>
<td>Group 1: Gluma Desensitizer Group 2: Nd:YAG laser Group 3: Nd:YAG laser followed by application of Gluma Desensitizer</td>
<td>None (not allowed by the ethics commission)</td>
<td>Before treatment, 5 minutes, 1 week, 1 month, 3 months, and 6 months after treatment.</td>
</tr>
<tr>
<td>Ozlem K et al, 2018</td>
<td>17 patients: 11 women and 6 men (100 hypersensitive teeth)</td>
<td>18-56</td>
<td>Group 1: Gluma Desensitizer Group 2: Nd:YAG laser Group 3: Gluma Desensitizer followed by Nd:YAG laser Group 4: Er,Cr:YSGG laser Group 5: Gluma Desensitizer followed by Er,Cr:YSGG laser</td>
<td>None</td>
<td>Before treatment, 30 minutes, 7 days, 3 months, and 6 months after treatment</td>
</tr>
<tr>
<td>Maximiano V et al, 2019</td>
<td>70 patients</td>
<td>18-65</td>
<td>Group 1: Prophylaxis with CSP paste (NovaMin) Group 2: Nd:YAG laser</td>
<td>Yes</td>
<td>Before treatment, 5 minutes, 1 week, 4 weeks after treatment</td>
</tr>
<tr>
<td>Miron M et al, 2020</td>
<td>7 patients (36 hypersensitive teeth)</td>
<td>22-35</td>
<td>Group 1: Amorphous calcium phosphate (ACP) Group 2: ACP followed by Nd:YAG laser</td>
<td>None</td>
<td>Before treatment, immediately after treatment, 24 hours, 7 days, 1 month after treatment.</td>
</tr>
</tbody>
</table>
Table 2. Results extracted from analyzed literatures

<table>
<thead>
<tr>
<th>Author, year</th>
<th>Clinical Parameter</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abed AM et al, 2012</td>
<td>Visual analog scale (VAS)</td>
<td>VAS scores did not show a significant difference between the three groups after treatment (p&gt;0.05). All VAS scores in post-treatment groups were significantly different from VAS scores in pre-treatment group (P&lt;0.05). A significant difference in the control group indicates a placebo effect. The effectiveness of treatment between the three groups was not significantly different. There is no significant difference between groups in each examination time. Air stimulus shows no significant difference between groups at each time interval. On long-term evaluation, all groups showed significant differences compared to baseline. Groups G2 and G3 show significant difference since the first evaluation. Group G1 showed a significant difference from the second evaluation (1 week). Comparison between groups using probe showed a significant difference in pain levels (p &lt; 0.05).</td>
</tr>
<tr>
<td>Lopes AO et al, 2013</td>
<td>Visual analog scale (VAS)</td>
<td>All post-treatment groups show a significant reduction of dentin hypersensitivity on every measurement interval. Er,Cr:YSGG laser with or without GCA shows the most effective result in treating dentin hypersensitivity (p&lt; 0.05). Comparison of treatment shows yeaple probe score on Nd:YAG laser group is not significantly higher than GCA group.</td>
</tr>
<tr>
<td>Ozlem K et al, 2018</td>
<td>Yeaple probe score</td>
<td>Significant reduction in dentin hypersensitivity was seen in all test groups at all time intervals. All three groups showed significant improvement immediately after treatment and 1 week after treatment (p&lt;0.001). The Nd:YAG laser group with DBA showed better effectiveness than other groups. The Nd:YAG laser group and the Nd:YAG laser group with DBA did not show a significant difference in the first and third months after treatment (p=0.05), but were more effective than the DBA group.</td>
</tr>
<tr>
<td>Guo L et al, 2018</td>
<td>Visual analog scale (VAS)</td>
<td>Pain reduction was shown at each time interval in all test groups when compared to baseline (p&lt;0.05). There was no significant difference between the experimental groups at each evaluated time interval (p&gt;0.05).</td>
</tr>
<tr>
<td>Maximiano V et al, 2019</td>
<td>Visual analog scale (VAS)</td>
<td>Pain reduction was shown at each time interval in all test groups when compared to baseline (p&lt;0.05). There was no significant difference between the experimental groups at each evaluated time interval (p&gt;0.05).</td>
</tr>
<tr>
<td>Miron M et al, 2020</td>
<td>Dental pulp vascular micro-dynamics by laser Doppler flowmetry (LDF) Verbal Rating Scale (VRS)</td>
<td>Pain reduction was shown at each time interval in all test groups when compared to baseline (p&lt;0.05). There was no significant difference between the experimental groups at each evaluated time interval (p&gt;0.05).</td>
</tr>
</tbody>
</table>
patients and at least 402 hypersensitive teeth were evaluated. Some studies only reported the number of subjects who met the inclusion criteria, but did not report the number of hypersensitive teeth, therefore a larger sample size is possible.

Table 2 showed that all literature presented a significant reduction in dentin hypersensitivity at follow-up immediately after the intervention up to 3 to 6 months after treatment. One article stated that the treatment of dentin hypersensitivity using NaF only started to show a significant reduction in the dentin hypersensitivity pain score (VAS) from the first week of follow-up. However, the use of glutaraldehyde as desensitizing agents showed better performance than the Nd:YAG laser in the reduction of dentin hypersensitivity (Yeeple score assessment) and suggested the use of the Er,Cr:YSGG laser combined with glutaraldehyde is more effective in treating dentin hypersensitivity. The dentin hypersensitivity assessment parameter used in the literature in this literature review was dominated by the visual analog scale (VAS), Yeeple score, and Laser Doppler Flowmetry (LDF). The results of the literature quality assessment in this literature review were carried out using JBI’s Checklist for Randomized Controlled Trials in Table 3.

### Discussion
Dentin hypersensitivity is a clinical condition that significantly interferes with a person’s quality of life in activities such as speaking, eating, drinking, or brushing teeth. Research by Bekes shows that dentin hypersensitivity significantly limits a person’s daily activities, which in turn has a major impact on a person’s quality of life. Along with the increasing number of articles published, various research methodologies are also used. Evaluation and diagnosis of dentin hypersensitivity itself can also be done with two types of assessment, namely stimulus-based and response-based. Assessment using stimuli such as thermal, tactile, or evaporative is the most commonly used for
dentin hypersensitivity. This literature review includes studies using the evaporative or tactile method, considering that this method is the most commonly reported, and the easiest to do and can be repeated, and is considered physiologically controllable. The Schiff Cold Air Sensitivity Scale (SCASS) or Schiff scale (SS) is used specifically to measure the degree of dentin hypersensitivity pain according to the patient's reaction after being given a stimulus. In SS, the subject's response is scored from 0 to 3, namely: 0 – does not respond to stimulus; 1 – the subject responds to the stimulus, but does not request that the stimulus be stopped; 2 – the subject responds to the stimulus and requests that the stimulus be stopped; 3 – the subject responds to the stimulus, and perceives the stimulus as painful, and requests that the stimulus be stopped. This scale is filled out by the operator or examiner. Response-based dentin hypersensitivity assessment generally uses and visual analog scale (VAS). VAS is considered one of the most frequently used methods of determining dental pain to obtain quantitative results. The variation in the use of the Yeaple score, VRS, or LDF laser can be an additional parameter to measure pain which is very subjective and individual.

According to Abed, a unique finding was that reduction in dentin hypersensitivity was found in the control group, which suggests a possible placebo effect in which subjects showed physiological changes after being given an inert agent. The effect of this phenomenon is difficult to assess but must be considered. The existence of information on the control group can provide additional information on the result interpretation of the effectiveness of the agent being tested. The use of active agents used in these articles such as potassium nitrate, glutaraldehyde, bonding agents, CSP, and ACP, or various fluoride materials are often used, and with their respective mechanisms generally show a reduction in dentin hypersensitivity after use. This shows the significant value of the treatment effect of these ingredients.

The Nd:YAG laser affects dentin hypersensitivity through the mechanism of fusion and resolidification of peritubular dentin. The advantage of HPL over LPL is that the photothermal mechanism melts and holds the hard tissue on its surface layer, thus closing the dentinal tubules and preventing the movement of fluid within the tubules. According to Soares, the Nd:YAG laser proved to be superior to 2% fluoride gels; however, research by Ozlem showed the Er,Cr:YSGG laser was superior, compared to Gluma and Nd:YAG. This may be because the obstruction of the dentinal tubules with this technique is more strongly accompanied with depolarization of the C afferent fibers, an effect produced by low-power diode lasers.

One of the limitations in this systematic review is the short follow-up period. A patient will expect the clinical treatment received to last as long as possible, at least until the maximum period of the material or treatment given so it will reduce the chance that the placebo effect will appear. In addition, the various parameters used to evaluate dentinal hypersensitivity, while providing additional information, may limit the conclusions reached.

Some recommendations that can be given for further research are age stratification because although most studies are conducted on subjects aged between 18 to 60 or 70, the incidence of dentin hypersensitivity varies greatly with age. A control group with placebo was suggested because of the possible reduction in dentin hypersensitivity contributed by the placebo effect. In laser treatment, placebo must be administered with a simulated treatment. In addition, a standardized technique for evaluating dentin hypersensitivity such as the distance of the air syringe to the tooth, duration, position, and air pressure applied during the evaporative test should be established to provide accurate results.

Conclusion
Considering the many treatment options available in treating dentin hypersensitivity including the variety of laser protocols, a general conclusion can be drawn that the use of the Nd:YAG laser is effective in reducing dentin hypersensitivity pain. However, it is not certain that this method will be the most effective strategy for the long-term effect. The most appropriate treatment for dentin hypersensitivity depends on a careful history and clinical examination, and the success of the treatment will depend on the clinician's ability to eliminate the causative factor with a treatment plan that is tailored to each individual.

Acknowledgment
None

Conflict Of Interest
The authors report no conflict of interest

References


