Laser-assisted treatment of dentinal hypersensitivity: a literature review

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Summary

The purpose of this literature review was to evaluate the effectiveness of the laser-assisted treatment of dentinal hypersensitivity. A review with inclusion and exclusion criteria was performed from January 2009 to December 2014 with electronic data-bases: MedLine via PubMed, Science Direct and Cochrane Library. Research of paper magazines by hand was not considered. Forty-three articles were selected between literature reviews, *in vitro* studies, clinical trials, pilot and preliminary studies. The items were divided into laser-used groups for an accurate description, and then the reading of results into various typologies. Laser-assisted treatment reduces dentinal hypersensitivity-related pain, but also a psychosomatic component must be considered, so further studies and more suitable follow-ups are necessary.

Key words: dentinal hypersensitivity, dentinal tubules, desensitizing agent, laser therapy.

Introduction

Dentinal hypersensitivity (DH), or cervical dentinal sensitivity, is a frequent clinical disorder. It is defined as pain arising from exposed dentine typically in response to thermal, chemical, tactile or osmotic stimuli, and it appears to be a common problem with various reports indicating an incidence between 4 to 74% among the population. The high variation in prevalence rate among most studies on dentin hypersensitivity should be explained by the bias concerning the highly selected population such as patients at dental clinics, students, or hospitalized patients (1-8).
Dentinal hypersensitivity may be caused by several conditions such as a result of periodontal pathologies, trauma, dental bleaching, professional oral hygiene, acid foods and beverages, bad oral hygiene habits or incorrect brushing techniques with consequent gingival recessions, etc. Even the removal of orthodontic fixed appliances could expose teeth to hypersensitivity. It seems that DH is rarely a result of just one of above factors, but rather a combination of more than one.
Patients are usually treated with topical desensitizing fluorine pastes and sealants. Even the aesthetic filling of eroded or exposed dental necks seems to be a good practice for pain reduction. Only in last decades these procedures have been supported by a laser-assisted treatment, often combined with classic desensitizing.
The use of lasers for DH treatment dates back to the '80s with the advent of the erbium laser. Although the initial results were quite disappointing, the improvement of technologies and scientific knowledge over the years optimized instrumentation and created new lasers with wavelengths suitable for the treatment (9-11).
Most of the studies conducted with various types of lasers, at different wavelengths and application times, reveal the effectiveness of this treatment, both immediately and during follow-up after approximately 6 months from the first treatment. As a result, the pain is reduced and in many cases it even disappears. Often the laser therapy is integrated with the use of desensitizing agents based on fluorine or newly discovered substances, and this can lead to an improvement in results (9, 12, 13).
Referring to the course of action, it was shown how the low-power lasers, including the GaAlAs diode laser with a wavelength between 780 and 900 nm, acts on the nervous level, thus eliminating the sensitivity. The medium-power lasers, including Nd:YAG, CO_2 and Er:YAG laser, desensitize causing narrowing and occlusion of dentinal tubules (10, 11).

The purpose of this literature review is to evaluate the effectiveness of the various types of lasers used in dentistry for the DH treatment, and to assess their validity both in the immediacy and after a follow-up.

Materials and methods

Research strategies

The following electronic databases have been evaluated: MEDLINE (via PubMed; www.ncbi.nlm.nih.gov/pubmed), Science Direct (www.sciencedirect.com) and the register of clinical trials and Cochrane reviews (Cochrane Library; www.cochranelibrary.com). There has been no research done manually with paper magazines. The time limit was from January 2009 to December 2014.
The databases were consulted using the following key words crossed in various ways:
(dental OR dentine OR tooth OR teeth OR cervix OR cement) AND (sensitive OR hypersensitivity) AND laser. Initially, the research was set without the use of Boolean values and removing the parentheses:
dental sensitive laser, dental hypersensitivity laser, dentine sensitive laser, dentine hypersensitivity laser, tooth sensitive laser, tooth hypersensitivity laser, cervical sensitive laser, cervical hypersensitivity laser, cement sensitive laser, cement hypersensitivity laser, teeth sensitive laser, teeth hypersensitivity laser.
The second type of research involved the Boolean value "AND":
dental AND sensitive AND laser, dental AND hypersensitivity AND laser, dentine AND sensitive AND laser, dentine AND hypersensitivity AND laser, tooth AND sensitive AND laser, tooth AND hypersensitivity AND laser, cervix AND sensitive AND laser, cervix AND hypersensitivity AND laser, cement AND sensitive AND laser, cement AND hypersensitivity AND laser, teeth AND sensitive AND laser, teeth AND hypersensitivity AND laser. The third type of the research has been carried out using both AND and OR Boolean values:
(dental OR dentine OR tooth OR teeth OR cervix OR cement) AND sensitive AND laser, (dental OR dentine OR tooth OR teeth OR cervix OR cement) AND hypersensitivity AND laser. The last research method was achieved by keywords:
laser, hypersensitivity without Boolean values. The research methodology has identified about 150 scientific papers.

Criteria

Exclusion criteria have been selected:
- presence of pediatric patients
- studies without complete statistical data
- at least 3 months' follow-up studies
- *in vivo* studies without measuring by Visual Analog Scale (VAS) and Verbal Rating Scale (VRS)
- case series
- case reports.

Inclusion criteria:
- *in vivo* and *in vitro* studies
- literature reviews, pilot studies, preliminary studies and clinical trials with and without use of placebo substances
- studies in which the laser-assisted desensitization treatment was effected by means of the medium- or low-power.

Results

Studies selection

Forty-three articles have been selected. The approach starts from selection between literature reviews, *in vitro* studies, clinical trials, pilot and preliminary studies *per annum*.
The items will be divided into laser-used groups for an accurate description, and then the reading of results into various typologies.

Nd:YAG laser

The efficiency of the Nd:YAG laser (neodymium-doped yttrium aluminium garnet; $Nd^{3+}:Y_3Al_5O_{12}$) and common desensitizing pastes for the reduction of the dentinal tubules lumen have been evaluated. Farmakis et al. (14) evaluated the efficacy of the Nd:YAG against a desensitizing paste (Novamine®). Subjects were divided into groups depending on the use of only paste, only laser (0,5 W) or both. The SEM analysis showed that the first group expressed greater occlusion of dentinal tubules than the second one. A year later, Farmakis et al. (15) proposed another study with different laser powers, both 0,5 and 1 W. In this case the 1 W laser, either alone or in combination with desensitizing paste, was more effective compared to 0,5 W laser.
Al-Saud and Al-Nahedh (16) used other types of desensitizing paste (Gluma®, TenureQuicl®, Quell and VivaSens®) instead and divided subjects in random groups in order to highlight that the best method to completely occlude or reduce the dentinal tubules diameter was Nd:YAG anyway.
An *in vivo* study evaluated the difference in reducing DH among the Nd:YAG laser and Gluma®. Patients were divided into three groups (only Gluma®, only laser and both) and pain levels were analyzed 5', 1 week, 1-3-6 months after with VAS. Although all protocols have demonstrated a marked reduction in pain even after six months, the combination of laser and paste remains the most significant treatment (17).
Some Authors introduced a potassium binoxalate gel and evaluated the efficacy in combination with laser or alone with VAS after cold air and hot water stimulation. Data were carried out immediately, 3-6-9 months after with the aid of electron microscope. Thanks to the merger of dentinal tubules, laser treatment is better in durability, even if the gel appears as a valid aid for its micro-crystals penetration (18).

Abded et al. divided subjects into three groups, with laser (1 W for 60''), with a new desensitizing agent (Seal & Protect™) and no-treatment. Thanks to the use of the SEM, the Author noted that the new resin was more effective than laser treatment (19).

Diode laser

In the last years, the diode laser (DL) has been the most used by dental hygienists during daily work. The literature contains a good amount of studies about this type of laser, particularly its effectiveness against dentinal hypersensitivity (20, 21).
Hashim et al. (22) carried out an *in vivo* study on 14 teeth of five different patients using a diode laser (0,5 W). Moreover, subjects have been divided into two groups based on laser exposure (30 and 60'') and checked 15' and seven days after. Authors demonstrated that the 60'' exposure is the most effective.
Often, this type of laser has been used in combination with 3% potassium nitrate or potassium oxalate gel (23-25). Even fluoride gels are often aid in the hypersensitivity treatment (26).
In 2012, Romeo et al. (27) divided subjects into three groups: with fluoride gel (60''), with 0,5 W laser and with both. The VAS reduction and better results over time were detected in both groups, although laser treatment reported a marked improvement over the initial situation.
Aranha et al. (28) compared different types of products. Gluma® has been applied for 30' with cotton swab on tooth surfaces (Heraeus Kulzer, Armonk, NY, USA), Seal & Protect™ (Dentsply, Petrópolis, RJ, Brazil) for 20'', 3% Oxa Gel potassium oxalate for 2' and APF (acidulated phosphate fluoride) for 1'. Lastly, the laser treatment has been used. Although all these protocols have led to a hypersensitivity reduction, laser therapy has very long term desensitizing effects.
The recent introduction of cyanoacrylate has invalidated the diode laser as the excellence therapeutic tool. Flecha et al. (29) have shown how cyanoacrylate has the same efficiency, but with lower cost and without side effects. Lin et al. (30) could evaluate how there are no real differences in terms of pain reduction between laser therapy, desensitization of the nerve or their combination.
A recent *in vitro* study, however, focuses on both the sealing ability and the potential danger of laser at the expanse of dental pulp. Umana et al. (31) have used different laser powers (0,8 - 1 - 1,6 - 2 W) on 24 extracted teeth and concluded that the 0,8 or 1 W laser irradiation for 10'' can seal dentinal tubules without damage.

Er:YAG and Er,Cr:YSGG lasers

A more thorough analysis reserved to the old and more powerful lasers, such as the Er:YAG (erbium-doped yttrium aluminium garnet; $Er^{3+}:Y_3Al_5O_{12}$) and the Er,Cr:YSGG (erbium, chromium: yttrium-scandium-gallium garnet; $Er^{3+}:Y_3Sc_2Ga_3O_{12}$).
The *in vitro* studies, after SEM observation, produced very positive results concerning the immediate occlusion of dentinal tubules. Aranha and Eduardo (32) set laser to a power of 0,25 and 0,5 W and highlighted carbonization and dentin fracture as well as lacking closure of dentinal tubules. Yilmaz et al. (33) confirmed immediate pain relief in the group treated with laser compared to placebo. The association between laser and glutaraldehyde desensitizing paste (Gluma®) confirms the usefulness of this treatment in the long term (up to 6 months later) (34).
Always Aranha and Eduardo (35) have divided 28 subjects into 4 groups. The first group received instructions about nutrition and oral hygiene, and no-power laser treatment (0 W), the second was treated with Er:YAG laser for 20'', while the third and fourth one with Er,Cr:YSGG (respectively with 0,25 and 0,5 W for 30''). Data underlined how each treatment reduces, although partially, the hypersensitivity pain, but treatments with 0,25 W Er,Cr:YSGG laser are the most efficient.
A recent study combines the laser sealing effect with a tooth paste nano-carbonate apatite made. Data are encouraging new research with statistical analysis and long-term results (36).

Comparison between different lasers

After the previous disquisition regarding studies on a single type of laser, associated or not to other agents, it is interesting to evaluate the comparative works between various commercial types of lasers. These studies are very heterogeneous, both in wavelengths and frequency used, for both samples and the treatment duration (37). Also in this section the effectiveness of CO_2 laser will be debated, despite the paucity of literature on its individual use in last years.
Romano et al. (38) indeed stress the sealing power of the CO_2 laser. Subjects have been divided into 7 groups and treated with only laser (0,5-1-1,5 W) or with laser and a calcium hydroxide paste. The tubular occlusion has been detected in each study group although the paste produced a higher reduction in hypersensitivity. Furthermore, samples treated exclusively with laser have also highlighted dentinal carbonization or cracks.
Two clinical studies, on the other hand, compared the CO_2 and Er:YAG lasers. Patients have been randomly assigned to the different groups, treated with only laser therapy, in association with fluoride gel or just placebo. The best results have been obtained with the aid of the laser in association to gel (39, 40).
In a comparative *in vitro* study the Er,Cr:YSGG (0,25 W), the Nd:YAG (1 W), the CO_2 (1 W) and the diode (810 nm, 2 W) lasers have been evaluated. Although a diameter reduction of dentinal tubules has been detected in all groups, the best result was obtained with Nd:YAG laser (53%) (41). Another study compares similar types of lasers: CO_2 and Er:YAG lasers are effective in treating DH and reducing its symptoms, even if the Er:YAG laser has a more significant effect (42).

Table 1. Summary of the main conclusions of the studies considered for the review.

Pro laser treatment	Against laser treatment
All types of laser treatments are more effective than traditional methods when used in association with gel or desensitizing tooth paste	Resins recently released onto the market appear to be in some studies more effective than laser treatment
Laser treatment combined with home therapy using a specific toothpaste produces longer lasting effects compared with traditional methods	Also some adhesives such as cyanoacrylate are more effective than laser
Compared with other lasers, diode lasers produce a gradual symptoms improvement that also lasts longer	SEM analysis show a similar reduction of the tubular diameter in both treatments
Other kinds of laser induce an immediate pain reduction, but the results don't last as long	The laser treatment can produce a significant placebo effect

Some Authors have shown the superiority of Nd:YAG, Er:YAG and CO_2 treatment compared to conventional topical products, but between these and the diode laser the situation is not well defined (43-46).
Taking into consideration the placebo effect, it is absent for the diode laser, Er:YAG and Nd:YAG, except the Er,Cr:YSGG results (47). Blatz (48) obtained further data: the Nd:YAG, Er:YAG and CO_2 laser-treatments are slightly higher than the classic desensitizing topical products, but Yilmaz et al. (49) in a randomized controlled clinical trial, highlighted the equal effectiveness of the diode laser (60'') and the Er,Cr:YSGG laser (30''). Therefore data indicated a small difference between two laser treatments, thus underlining contradictions in literature.
Table 1 summarizes the main conclusions of the studies included in this review.

Discussion

This literature review proposes to analyze recent years' publications, although they were a lot and sometimes at odds with each other, related to different lasers for dental hypersensitivity treatment.
The laser-assisted treatment of dentine hypersensitivity is a good method to solve immediate and long-term pain. Compared to conventional desensitizing topical agents, the laser treatment, although more expensive, leads to rapid results with less application time and more quickly for the patient. In most of the articles, fluoride gel or desensitizing substances used in combination with laser light can potentiate effects. The same line of reasoning is considered valid for the association with desensitizing pastes.
New substances as cyanoacrylate, glutaraldehyde and potassium binoxalate are spreading for the properties to stimulate laser beneficial effects and they can be used alone as preventative measures in patients with mild hypersensitivity. However, the effectiveness of these treatments has clashed sometimes with the existence of a placebo effect.
In the majority of studies, patients have a decrease in VAS from baseline both immediately and over time, till six months after treatment.
The diode laser appears to be the most widely used in everyday practice by dental hygienists and dentists. Studies are clarifying the follow-up results within the interference of the placebo effect. The DL has specific wavelengths resulting very safe for the patient and, above all, not causing side effects or damage on the pulp as it is the case in older and powerful systems such as Er,Cr:YSGG or Er:YAG lasers.
However, *in vitro* studies confirm a real effectiveness of these lasers. Thanks to the SEM analysis, the percentage of occlusion appears to be complete and the diameter of dentinal tubules reduced (50, 51).

Conclusions

Although it would seem that the laser treatment effectively reduces pain symptoms, further studies and more suitable follow-ups are necessary. Another important consideration regards the reduced presence of side effects in the matter of new generation lasers, already set up by the manufacturer and supplied with specific protocols for each treatment. The Diode Laser has to be preferred for DH treatment thanks to its use in safety and beneficial clinical results.
More clarity should be obtained on the topic "placebo effect". In many cases it was found that patients undergoing placebo still receive benefits with a reduction of the VAS values. These considerations do not exclude a psychosomatic component of dentinal hypersensitivity.
In consideration of all data gathered, it can be said that laser is an innovative and faster treatment both in terms of therapy time and results, with minimal side effects and greater comfort for patients, which appear more satisfied with traditional methods.

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