

# Phototherapy Using Er,Cr:YSGG Laser as a Definitive Treatment for Dentin Hypersensitivity: A Systematic Review

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**Purpose:** To assess the efficacy of Er,Cr:YSGG lasers in reducing dentine hypersensitivity (DH).

**Methods:** Electronic literature were searched through various databases (MEDLINE, SCOPUS, ProQuest, LILACS and EBSCO) up to March 2022 for articles addressing the following focused question: “In patients with dentine hypersensitivity, does an Er,Cr:YSGG laser provide a better outcome in terms of pain reduction than other dentine desensitizer agents?”. The literature was searched using combinations of the following medical subject heading (MeSH) terms and keywords: (laser OR phototherapy OR Er,Cr:YSGG laser) AND (dentine hypersensitivity OR dentine sensitivity OR dental sensitivity).

**Results:** A total of 486 studies were found, of which 7 randomized controlled trials were included in the review. The Er,Cr:YSGG laser wavelengths, power density and duration of irradiation used in the studies were 2780 nanometers, 0.25–0.5 watts and 20–60 seconds, respectively. The follow-up assessments were conducted ranging from immediately to 3 months after treatment. All studies showed that the Er,Cr:YSGG laser was effective in alleviating DH.

**Conclusion:** This systematic review suggests that the application of an Er,Cr:YSSG laser is effective in alleviating DH and may have limited adverse effects if adequate parameters are followed.

**Keywords:** phototherapy, dentine hypersensitivity, dentine sensitivity, Er,Cr:YSGG laser

## Introduction

Dentinal hypersensitivity (DH) is known as one of the most irritating clinical conditions.<sup>1</sup> DH felt by patients as sharp pain emanating from exposed dentin in reaction to warm, evaporative, material, electrical, osmotic or chemical insult.<sup>2</sup> This condition commonly involves the cervical third of canines and premolar facial surfaces.<sup>3</sup> Additionally, DH may be the result of dentin exposure due to enamel or cemental loss, the former of which occurs due to improper tooth brushing techniques, dietary erosion, abfraction, and parafunctional habits, while, gingival recession, periodontal disease, root planing and periodontal surgery will result in cemental loss.<sup>4–6</sup>

Many theories have been proposed to clarify the causes of DH. One among the foremost widely accepted is Braennstroem’s 1984 hydrodynamic theory, which relates the cause of DH to the increase of the fluid flow inside the dentinal tubules after the application of a cold stimulus.<sup>7</sup> This fluid movement will elicit the nerve ending within dentinal tubules causing pain.<sup>8</sup> Due to its multifactorial nature, DH diagnosis and treatment is complex. Hypersensitive teeth should, therefore, be examined carefully to ensure pulpal and gingival health.<sup>9</sup> Dentin with hypersensitivity displays enlarged tubules and more tubules per surface area than dentin without sensitivity, causing discomfort and disrupting quality of life.<sup>10</sup>

Various methods of treating dentin hypersensitivity were mentioned in the literature and to be utilized they must meet certain criteria at least, such as ease of application, lack of irritability to the pulp, painlessness, rapid action, permanent

effects on the dentin, and affordability. Desensitization can be accomplished by blocking pulpal sensory nerves or occluding open dentinal tubules.<sup>4,11</sup> Potassium nitrate, silver nitrate, and strontium chloride desensitizing agents work by blocking synapses between nerve cells, thereby reducing nerve activation and pain. Many substances, including sodium fluoride, potassium oxalate, and calcium phosphate, have been shown to occlude dentinal tubules. Varnishes, cements, adhesive materials, and some laser types have also been known to occlude the dentinal tubules.<sup>4</sup>

Recently, lasers have been used as an alternative for DH treatment and have become a focus of interest for research in recent decades.<sup>11,12</sup> There are several types of lasers used in dentistry, which are classified as hard lasers or soft lasers. Carbon dioxide (CO<sub>2</sub>) lasers, neodymium: yttrium aluminum garnet (Nd: YAG) lasers, and erbium: yttrium aluminum garnet lasers (Er: YAG) are examples of hard lasers. Low-level laser therapy (LLLT) or biostimulation are terms used to describe soft lasers based on semiconductor diode devices.<sup>13</sup> Lasers are used for soft tissue as in periodontal treatments, therapy of oral malignancies, orthodontic treatments, and miscellaneous tissue removal in oral medicine. Lasers have also been developed to be used in hard tissue treatment, such as cavity preparation and caries and restorative material removal, along with the treatment of dentinal hypersensitivity.<sup>13,14</sup>

The erbium, chromium:yttrium, scandium, gallium, garnet laser (Er,Cr:YSGG) has a 2780 nm wavelength<sup>15</sup> and provides advantages for both the care provider and recipient. Er,Cr:YSGG is a painless, safe and precise laser that is used for hard and soft tissue treatments.<sup>12,16</sup> As explained by Yilmaz et al<sup>17</sup> in 2011, the Er,Cr:YSGG laser demonstrates increased absorption in water, which results in evaporation of dentinal fluids. This action leads to the insoluble salt deposition in the exposed dentinal tubules to occlude them.<sup>17</sup>

A systematic review of the literature is required to determine whether lasers are more effective than a placebo or no treatment in reducing DH. As a result, the primary goal of this systematic review is to determine the efficacy of phototherapy, particularly Er,Cr:YSGG laser therapy, in reducing DH.

## Materials and Methods

### Protocol Registration and Focused PICO Question

This systematic review was registered at the National Institute for Health Research PROSPERO, International Prospective Register of Systematic Reviews, registration number: CRD42021255945. This systematic review was conducted based on the “Preferred Reporting Items for Systematic Review and Meta-Analysis” (PRISMA) guidelines.<sup>18</sup> The PICO principle (ie, “Patients” – adults with dentine hypersensitivity; “Interventions” – Er,Cr:YSGG laser “Comparisons” – other dentine desensitizer agent or no treatment group; “Outcomes” – dentine hypersensitivity reduction) was used to develop and answer the following focused question: “In patients with dentine hypersensitivity, does the Er,Cr:YSGG laser provide better outcomes in terms of pain reduction than other dentine desensitizer agents?”

### Selection Criteria

The following were the inclusion criteria: (1) randomized controlled trials (RCTs); (2) adult patients (aged 18 years) with DH; (3) comparator group including subjects who were exposed to other dentine desensitizer agents or no treatment. The exclusion criteria included (a) subjects with systemic diseases; (b) studies without quantitative data; (c) studies without a scale or score to measure dentine hypersensitivity; and (d) studies with incomplete irradiation protocols (wavelength, power, energy density, frequency, mode, air and water percentages).

### Search Strategy

Electronic literature searches were conducted in various databases (MEDLINE; SCOPUS; ProQuest; LILACS; and EBSCO) up to March 2022 for articles published in English addressing the focused question. The combinations of the following medical subject heading (MeSH) terms and keywords were used to search the literature: MEDLINE (((laser therapy[MeSH Terms]) OR (phototherapy[MeSH Terms]) OR (Er,Cr:YSGG laser[MeSH Terms])) AND ((dentin sensitivity[MeSH Terms]) OR (dentin hypersensitivity[MeSH Terms]))); EBSCO ((laser) Subject AND (dentine sensitivity) Subject OR (dentin hypersensitivity) Subject); SCOPUS (KEY ((laser OR phototherapy)) AND KEY ((dentin sensitivity OR dentin hypersensitivity)); LILACS (dentine sensitivity OR dentin hypersensitivity) [Subject descriptor] AND (laser

or phototherapy) [Subject descriptor]; ProQuest ((main subject (dentine sensitivity OR dentin hypersensitivity) AND main subject (phototherapy or laser)).

## Screening Methods and Data Extraction

Article titles and abstracts that met the inclusion criteria were screened and evaluated. The information from the included studies was extracted as follows: first author and year of publication, study design (parallel or split-mouth), type of treatment, number of teeth and subjects, mean difference of pain and percentage of DH reduction, both between baseline and follow-up, and any recorded adverse effects.

## Risk of Bias and Quality Assessments

The quality of RCT methodologies of the included studies was evaluated in accordance with the Cochrane risk-of-bias tool for randomized trials (RoB 2).<sup>19</sup> The following domains were evaluated: the process of randomization, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result. The bias was then classified into low risk of bias (when all criteria were fulfilled), high risk of bias (when  $\geq 1$  criterion was not fulfilled), and some concerns (when  $\geq 1$  criterion was partially fulfilled).

## Results

### Study Selection

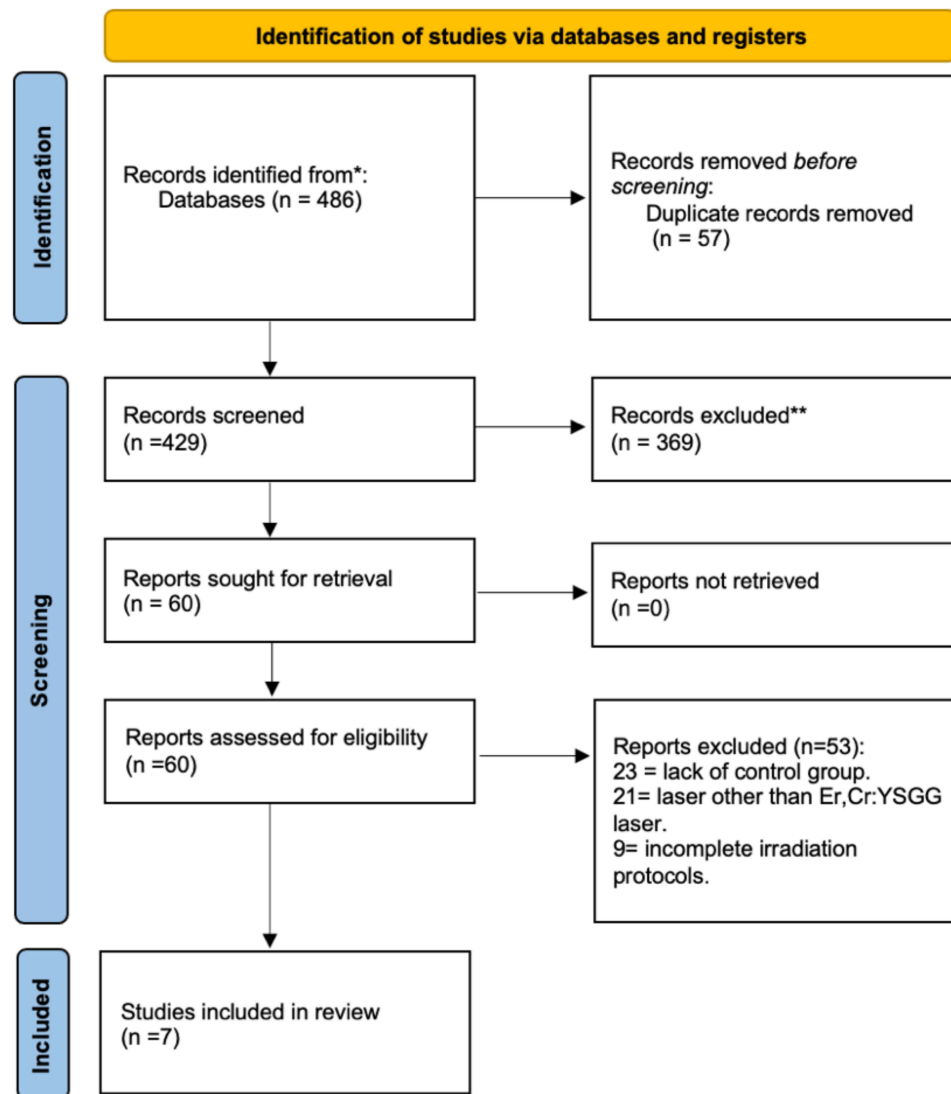
The electronic search initially revealed 486 potential studies according to their titles and abstract in the following databases: PubMed (n = 174), LILACS (n = 6), ProQuest (n = 15), SCOPUS (n=187), and EBSCO (n = 104). Fifty-seven studies were removed from the selection process as they were identified as duplicate studies. According to abstract screening results, 369 articles did not meet the objectives of the current review and were therefore excluded. Sixty articles were retrieved and downloaded for full review. Out of these 60 articles, 53 studies were further removed because they did not meet the inclusion criteria. The final selection of studies resulted in the inclusion of 7 RCTs for qualitative assessment.<sup>17,20–25</sup> Figure 1 shows the detailed flow diagram of the study selection process according to the PRISMA recommendations and guidelines.<sup>26</sup>

### General Characteristics of the Included Studies and Laser Parameters

Table 1 presents the general characteristics of all RCTs included. Three studies were conducted in the United States,<sup>17,22,25</sup> 2 studies were conducted in Iran,<sup>20,23</sup> 1 study was performed in Brazil<sup>21</sup> and 1 study was performed in Turkey.<sup>24</sup> Studies included in this review compared one type of laser with a placebo, another desensitizing agent or another type of laser. All publications were in English (Table 1). Four of the included studies<sup>20,21,23,24</sup> followed a parallel study design, and the other three<sup>17,22,25</sup> adopted a split mouth design. All of the studies were conducted at a university. Generally, all the RCTs included diagnosing dentine hypersensitivity similarly using air stimuli, A visual analog scale (VAS) was used to measure patients' overall sensitivity, except for Ozlem et al,<sup>24</sup> who used a precalibrated Yealp probe, and Aranha and de Paula Eduardo,<sup>21</sup> who used slight probe pressure in addition to the air stimulus.

The Er,Cr:YSGG laser parameters/settings that were used in the RCTs are shown in Table 2. The follow-up assessments were conducted ranging from immediately to 3 months after treatment. Five of the studies<sup>17,20,22,24,25</sup> reported no relevant adverse events after laser application. The other two studies,<sup>21,23</sup> no information was disclosed about the occurrence of any adverse events. All the included studies reported that the use of the Er,Cr:YSGG laser decreased the pain level and dentine hypersensitivity.

All included studies<sup>17,20–25</sup> presented an appropriate randomization process, outcome measurement, and selection of the reported result. The risk of bias was considered low for all included RCTs in accordance with the recommendation of the Cochrane Handbook for Systematic Reviews of Interventions<sup>19</sup> (Table 3).



**Figure 1** PRISMA flowchart of the search strategy.

**Notes:** Adapted from Page MJ, McKenzie JE, Bossuyt PM et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71. doi:10.1136/bmj.n71.<sup>18</sup> Copyright 2021 Page et al. Creative Commons CC BY 4.0 (<https://creativecommons.org/licenses/by/4.0/legalcode>).

## Discussion

The present systematic review tested the hypothesis that an Er,Cr:YSGG laser is more effective than placebo or other in-office treatments for DH. According to our knowledge, this is the first systematic review to evaluate the effectiveness of an Er,Cr:YSGG laser per se in treating DH. This systematic review revealed that the Er,Cr:YSGG laser reduced DH in all of the studies compared to baseline, demonstrating that this treatment is effective in reducing DH.

Lasers with different power ranges have shown to be an effective treatment of DH.<sup>27,28</sup> Er, Cr:YSGG is among the most used lasers in DH treatment and have shown a good result in relieving pain caused by DH.<sup>29</sup> The efficacy of Er,Cr:YSGG laser in treating DH is owed to the increased absorption of its wavelengths (2780 nm) by water, which can evaporate dentinal fluid from the exposed tubules.<sup>17</sup> Thus, the flow movement is reduced, and insoluble salts are formed that seal the dentinal tubules. Another proposed Er,Cr:YSGG laser mechanism is its impact on transient receptor potential channels (TRPV1), which are known to be affected by thermal stimuli.<sup>30,31</sup>

Notably, the included studies demonstrated heterogeneity in study design, laser parameters, duration of application, stimulation method, and follow-up time. However, the utilization of Er,Cr:YSGG laser was effective in treating DH without any adverse reactions in most of the protocols used in these studies.

**Table 1** General Characteristics of the Studies That Were Included in the Review

Author/ Year	Place	Number of Subjects	Number of Teeth	Study Design		Stimulus	Mean Difference of Pain Assessment Scores Between Baseline and Follow-Up	Percentage of DH Reduction Between Baseline and Final Follow-Up	Adverse Effects
Moeintaghavi et al <sup>20</sup> 2021	Iran	24	NR	PD	G 1: InGaAlP and GaAlAs laser (200mW) G 2: Er,Cr:YSGG (Two applications 15 min apart 0.25 W & 0.5 W) G 3: fluoride varnish G 4: low level laser therapy without emission	Air stimulus	-1.1 -4.33 -2.1 1	-17% -55% -29.1% 14%	No
Aranha and de Paula Eduardo <sup>21</sup> 2012	Brazil	28	7 7 7 7	PD	G 1: control G 2: Er:YAG (0.64 W, 5.9 J/ cm <sup>2</sup> ) G 3: Er,Cr:YSGG (0.25W, 4.4 J/cm <sup>2</sup> ) G 4: Er,Cr:YSGG (0.5W, 8.9J/cm <sup>2</sup> )	Air stimulation and pressure	0.56 0.22 0.69 -0.2	29% 22% 43.9% -10%	NR
Ozlem et al <sup>24</sup> 2018	Turkey	17	100	PD	G 1: gluma desensitizer (GCA) G 2: Nd:YAG (1W/cm <sup>2</sup> , 4.4 J/cm <sup>2</sup> ) G 3: gluma desensitizer (GCA) followed by Nd: YAG (1W/cm <sup>2</sup> , 4.4 J/cm <sup>2</sup> ) G 4: Er,Cr:YSGG (0.25W, 4.4 J/cm <sup>2</sup> ) G 5: gluma desensitizer (GCA) followed by Er,Cr: YSGG (0.25 W, 4.4 J/cm <sup>2</sup> )	Precalibrated Yeable probe	28.65 44.4 51.9 71.3 72	191% 319% 411% 472% 660%	No
Pourshahidi et al <sup>23</sup> 2019	Iran	17	34	PD	G 1: Diode laser (940nm) G 2: Er,Cr:YSGG (0.25W, 4.4 J/cm <sup>2</sup> )	Air spray with pressure of 45–60 psi for 35s from 2 mm distance and an explorer	-5.33 -6.41	-65% -79%	NR

(Continued)

Table 1 (Continued).

Author/ Year	Place	Number of Subjects	Number of Teeth	Study Design		Stimulus	Mean Difference of Pain Assessment Scores Between Baseline and Follow-Up	Percentage of DH Reduction Between Baseline and Final Follow-Up	Adverse Effects
Yilmaz et al <sup>17</sup> 2011 (JCP)	USA	42	146	SM	G 1: Er,Cr:YSGG used without emission (control) G 2: Er,Cr:YSGG (0.25W, 4.4 J/cm <sup>2</sup> )	Air stimulus	-0.79 -5.67	-11.4% -80.7%	No
Yilmaz et al <sup>22</sup> 2011	USA	51	174	SM	Control (no treatment) Er,Cr:YSGG (0.25 W, 4.4 J/ cm <sup>2</sup> ) GaAlAs diode laser (810nm, 8.5 J/cm <sup>2</sup> )	Air stimulus	-0.5 -6.2 -6	-7.2% -86.1% -84.5%	No
Yilmaz and Bayindir <sup>25</sup> 2014	USA	20	60	SM	G 1: Er,Cr:YSGG used without laser emission (control) G 2: Er,Cr:YSGG (0.25W, 4.4 J/cm <sup>2</sup> ) G 3: Er,Cr:YSGG (0.5W, 8.9J/cm <sup>2</sup> )	Air stimulus	-0.18 -4.89 -6.41	-2.3% -61.8% -81.5%	No

**Abbreviations:** PD, parallel study design; SM, split mouth study design; NR, not reported.

**Table 2** Er,Cr:YSGG Laser Parameters in the Included Studies

Author/Year	Power (W)	Frequency (Hz)	Pulse Duration ( $\mu$ s)	Energy Density (J/cm <sup>2</sup> )	Tip Size	Water	Air	Application Time
Moeintaghavi et al <sup>20</sup> 2021	Two applications 15 min apart 0.25 W & 0.5 W	25 Hz	140 $\mu$ s	–	MZ6 sapphire	No	No	Each application 10s
Aranha and de Paula Eduardo <sup>21</sup> 2012	G3: 0.25 W G4: 0.5 W	20 Hz	140–200 $\mu$ s	4.4 8.9	MZ6 sapphire	No	No	30 s
Ozlem et al <sup>24</sup> 2018	0.25 W	20 Hz	–	44.3	Z6 sapphire	No	No	30 s
Pourshahidi et al <sup>23</sup> 2019	0.25 W	50 Hz	140 $\mu$ s	4.4	–	No	No	1 min
Yilmaz et al <sup>17</sup> 2011 (JCP)	0.25 W	20 Hz	–	4.4	MZ6 sapphire	No	10%	30 s
Yilmaz et al <sup>22</sup> 2011	0.25 W	20 Hz	140 $\mu$ s	4.4	MZ6 sapphire	No	10%	30 s
Yilmaz and Bayindir <sup>25</sup> 2014	G1: 0.25 W G2: 0.5 W	20 Hz	140 $\mu$ s	4.4 8.9	MZ6 sapphire	No	10%	30 s

**Table 3** Results of the Cochrane Risk of Bias Assessment of the Included RCTs

Domain	Moeintaghavi et al <sup>20</sup>	Aranha and de Paula Eduardo <sup>21</sup>	Ozlem et al <sup>24</sup>	Pourshahidi et al <sup>23</sup>	Yilmaz et al <sup>17</sup> (JCP)	Yilmaz et al <sup>22</sup>	Yilmaz and Bayindir <sup>25</sup>
<b>Domain 1: Risk of bias arising from the randomization process</b>	Low	Low	Low	Low	Low	Low	Low
Domain 2: Risk of bias due to deviations from the intended interventions	Low	Low	Low	Low	Low	Low	Low
Domain 3: Missing outcome data	Low	Low	Low	Low	Low	Low	Low
Domain 4: Risk of bias in measurement of the outcome	Low	Low	Low	Low	Low	Low	Low
Domain 5: Risk of bias in selection of the reported result	Low	Low	Low	Low	Low	Low	Low

**Notes:** Cochrane risk of bias assessment table adapted from: Sterne JAC, Elbers RG, Page MJ, et al. Assessing risk of bias in a randomized trial. In: Higgins JPT, Thomas J, Chandler J, et al. *Cochrane Handbook for Systematic Reviews of Interventions*. Hoboken: John Wiley & Sons; 2019.<sup>19</sup> Copyright © 2019 The Cochrane Collaboration.

Moeintaghavi et al<sup>20</sup> reported that Er,Cr:YSGG laser treatment resulted in a reduction in pain severity immediately and 1 week after treatment that was greater than that produced by Galium, Aluminum, Phosphor (GaAlP) laser therapy, fluoride varnish, and placebo tests. Pourshahidi et al<sup>23</sup> also found that pain severity decreased significantly immediately after treatment in comparison with a diode laser, but no further statistically significant decreases at the 1-week or 1-month follow-up were observed. Furthermore, Yilmaz et al<sup>22</sup> demonstrated that both Er,Cr:YSGG, and GaAlAs lasers resulted in a reduction in DH immediately after treatment that was maintained throughout the study with no significant differences



between the laser groups. Yilmaz et al<sup>17,25</sup> reported an immediate pain level reduction following Er,Cr:YSGG use compared with the placebo. Moreover, Aranha and de Paula Eduardo<sup>21</sup> found that the Er:YAG and Er,Cr:YSGG treated groups had pain reduction immediately after treatment. However, 0.5 W Er,Cr:YSGG laser radiation showed the most pronounced immediate effect on DH reduction. Similarly, the study by Ozlem et al<sup>24</sup> showed that hypersensitivity could be reduced by a range of different interventions, including the use of a glutaraldehyde containing agent and Nd:YAG, and Er,Cr:YSGG lasers. Despite the good results with the other treatment modalities, there seemed to be a better effect when the Er,Cr:YSGG laser is employed.

The results of this systematic review are consistent with those from a previous meta-analysis,<sup>29,32</sup> which reported that lasers were more efficient than placebo for DH treatment. Similarly, Rezazadeh et al's systematic review reported that a high-level laser was effective for the treatment and prevention of DH.<sup>33</sup> Additionally, several systematic reviews report that the Er,Cr:YSGG laser is effective in the treatment of DH and maintaining its efficacy over time.<sup>27,29,34</sup> However, the results of this systematic review are in contrast to those from that conducted by Sgolastra et al,<sup>35</sup> in which the evidence of the effectiveness of laser treatment was weak and the placebo effect could not be ruled out. Notably, only 3 RCTs were included in that review.<sup>35</sup> Moreover, a meta-analysis performed by Sgolastra et al<sup>36</sup> found a minimal clinical difference between Er,Cr:YSGG laser and placebo treatments. However, because only 3 RCTs using Er,Cr:YSSG laser therapy were included, the capacity to detect significant differences may have been limited.<sup>36</sup>

The number of studies included in the systematic review, the small sample sizes, little or no follow-up, and the lack of control groups were the study's main shortcomings. The current systematic review included only English-language papers, which might have resulted in publication bias, with significant studies published in other languages being overlooked.<sup>37</sup> Furthermore, due to the methodological heterogeneity of the included papers, no meta-analysis could be performed.

## Conclusions

This systematic review suggests that the utilization of an Er,Cr:YSSG laser is efficient in reducing DH and may have limited adverse effects if adequate parameters are followed. However, owing to the considerable heterogeneity and small number of included studies, the current review's findings should be interpreted with caution. To confirm the beneficial therapeutic effect of the Er,Cr:YSSG laser, a long-term RCT with a large sample size should be performed.

## Abbreviations

DH, dentine hypersensitivity; MeSH, medical subject heading; CO<sub>2</sub>, carbon dioxide; Nd, YAG, neodymium: yttrium, aluminum, garnet; Er: YAG, erbium: yttrium, aluminum, garnet; LLLT, low-level laser therapy; Er,Cr:YSGG, erbium, chromium: yttrium, scandium, gallium, garnet laser; PRISMA, preferred reporting items for systematic review and meta-analysis; RCTs, randomized clinical trials; VAS, visual analog scale; TRPV1, transient receptor potential channels; GaAlP, gallium, aluminum, phosphor.

## Data Sharing Statement

The data of this review will be shared upon valid request to the corresponding author.

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## Disclosure

The authors declare no conflicts of interest in relation to this work.

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