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Effect of Low- and High-Level Laser Therapy on the Treatment of Dentin Hypersensitivity: An Umbrella Review

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Abstract

Introduction: Dentin hypersensitivity (DH) is a prevalent unpleasant condition which might affect quality of life. Laser therapy is one of the non-invasive treatments for dentin hypersensitivity. The aim of this umbrella review was to assess the effect of lasers on the treatment of dentin hypersensitivity by analyzing the previously published systematic reviews and meta-analyses.

Methods: Electronic databases (PubMed, Embase, Scopus, Cochrane, and ISI) were searched to identify relevant systematic reviews and meta-analyses based on the keyword search strategy. Two independent reviewers carried out the selection of studies, extraction of data, and assessment of methodological quality. The actual overlap of primary studies was measured through the visual tool known as the citation matrix and three indices of % overlaps, covered area (CA), and corrected covered area (CCA). The reviews were appraised for methodological quality through A Measurement Tool to Assess Systematic Reviews (AMSTAR)-2, and the risk of bias was evaluated using the Risk of Bias in Systematic Reviews (ROBIS) tool.

Results: Following eliminating duplicates, a total of 2,768 articles were found, and of them, 9 systematic reviews met the inclusion criteria. Six of them included a meta-analysis as well. The actual overlap of primary studies was low. The AMSTAR 2 tool classified one systematic review as high quality, three as moderate quality, three as low quality, and the remaining two as critically low quality. The results of the included reviews generally showed that all types of lasers reduced dentin hypersensitivity compared to placebo/no treatment.

Conclusion: Lasers are effective in treating dentin hypersensitivity.

Keywords: Dentine hypersensitivity; Lasers; Meta-analysis; Systematic review; Umbrella review.

Introduction

Dentin hypersensitivity (DH) is an unpleasant clinical condition which is felt as sharp pain originating from exposed dentin in reaction to thermal, evaporative, chemical, physical, osmotic, material or electrical stimuli.[1,2] At least 10% of the population is experiencing DH and it might affect their quality of life (QoL).[3] The main factor contributing to DH is the loss of enamel and the subsequent exposure of dentine due to physiological enamel abrasion or gingival tissue recession.[4] The mechanism responsible for DH has yet to be completely understood [5]. The hydrodynamic theory, suggested by Brannstrom and Astrom, is widely acknowledged as the most accepted hypothesis.[5–8] This theory suggests that the majority of pain-inducing stimuli cause a rise in centrifugal movement of fluid within the dentinal tubules, leading to a pressure change that affects the entire dentin.[5]

There are numerous strategies to prevent and treat DH: (1) Oral hygiene instructions; (2) Behavioral control and removal of predisposing factors; 3) Non-invasive treatment methods for pain relief; (4) Restoration or surgical treatments.[9] Administration of desensitizing agents and laser therapy are the non-invasive treatments for DH.[9] Light Amplification by Stimulated Emission of Radiation (Laser) has become an interesting area of research in recent decades.[10] Several types of lasers have been referenced in the literature as treatments for DH, including He–Ne, diode, Nd:YAG (neodymium-doped yttrium aluminium garnet), Er:YAG (erbium-doped yttrium aluminium garnet), Er,Cr:YSGG (erbium, chromium-doped yttrium scandium gallium garnet), KTP (potassium-titanyl-phosphate), and CO2 (carbon dioxide) lasers.[11] The mechanism of lasers is the obliteration of dentinal tubules when used at high intensity and the rise of

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the excitability threshold of nerve endings and metabolic activity of odontoblasts to create restorative dentin when used at low intensity.[10]

Several randomized clinical trials have shown that a significant decrease in DH occurred with the application of lasers.[12-14] However, some other trials suggested that laser and placebo treatments for DH did not differ significantly in statistical terms.[15,16] To better comprehend the contradictory outcomes, researchers have conducted numerous systematic reviews with or without meta-analyses to assess the impact of lasers on DH. One of the first systematic reviews comparing the effectiveness of lasers with that of topical desensitizing agents concluded that lasers have a modest clinical benefit over desensitizing agents in the management of DH.[17] Another review indicated that while laser treatment alleviates DH, evidence supporting this effectiveness is not strong, and it is crucial to consider the potential influence of the placebo effect.[18] Some other reviews concluded that different kinds of lasers had significantly better outcomes than negative controls for DH after the treatment and in the long term.[8,19,20]

An umbrella review incorporates the strongest evidence available, that is to say, systematic reviews and meta-analyses, to highlight the consistency or conflict of the data on a particular subject and to investigate the reasons for the findings.[21] Umbrella reviews consider comparisons of multiple treatments for the management of a particular disease or condition.[22] Currently, there is a daily publication of 75 trials and 11 systematic reviews of trials, and this upward trend has not yet hit a plateau.[23] The exponential growth in the number of systematic reviews published on identical topics within a single year and inconclusive outcomes make it difficult for decision-makers to determine where to base their conclusions.[24] Thus, umbrella reviews are established to synthesize available systematic reviews and to fulfill the need for a comprehensive approach.[24] Up until now, many systematic reviews and meta-analyses have analyzed the effect of lasers compared with placebo in the management of dentin hypersensitivity. However, the large number of these studies and the contradictory results make it difficult for practitioners to conclude whether lasers are effective and decide which type of laser they should use in the treatment of DH. As far as we know, there has been no umbrella review undertaken to analyze the findings from systematic reviews and meta-analyses involving the effect of lasers on DH. Therefore, performing an umbrella review in the field is necessary to make a conclusion from the results of previous studies. The aim of this study was to analyze the outcomes of prior systematic reviews with or without meta-analyses to (1) figure out whether high- and low-level lasers are effective compared to placebo/no treatment in reducing dentin hypersensitivity measured by the visual or verbal analog scale and (2) evaluate which type of laser has the most therapeutic effect in treating DH.

Methods

Registration

This umbrella review was performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The PROSPERO database has this review's protocol registered under the number CRD42023395922.

Review Questions

The review questions were formulated according to the PICO (population, intervention, control and outcome) methodology (Table 1): Is the application of laser effective in the management of dentin hypersensitivity compared to placebo/no treatment? What kind of laser is more effective in treating dentin hypersensitivity?

Selection Criteria

Systematic reviews and meta-analyses available in the English language that evaluated the effect of lasers on dentin hypersensitivity were included. Clinical trials, non-systematic reviews, animal studies, experimental studies, case reports, and case series were excluded.

Search Strategy

An electronic data search was carried out in five databases including PubMed, Embase, Scopus, Cochrane, and ISI (All databases) up to 8 November 2022. No language or publication period limitation was applied. The search strategy described below was used: (teeth OR tooth OR oral OR mouth OR dent*) AND (hypersensitivity OR sensitivity) AND (Desensiti* OR Dentifrices OR Toothpastes OR Mouthwashes OR (In-office treatment) OR Fluorides OR Arginine OR Calcium OR Phosphates OR Silicates OR Potassium OR Nitrates OR Oxalates OR Strontium OR Titanium OR Aluminum OR Hydroxyapatites OR Nanohydroxyapatite OR Durapatite OR Casein OR Glutaraldehyde OR Gluma OR (Bioactive glass) OR Propolis OR Laser* OR (Light amplification by the stimulated emission of radiation) OR (Low-Level Light Therapy) OR (High-Level Light Therapy) OR Phototherapy OR Photobiomodulation) AND (Pain OR VAS OR (Verbal analog scale) OR (Prevention & control) OR Therap* OR Outcome OR Effectiveness) AND (review OR meta-analysis OR meta analysis).

Table 1. PICO Methodology for the Review Questions

Population	Patients with dentin hypersensitivity
Intervention	Lasers
Comparison	Placebo/No treatment
Outcome	Reduction in dentin hypersensitivity measured by the visual or verbal analog scale

Study Selection

Titles and abstracts of the papers found were examined by two independent reviewers and they decided whether to include or exclude them. If doubt was raised following reviewing the title and abstract of each review, the full text was considered to determine the eligibility. The assistance of a third reviewer was used to settle disagreements between the two reviewers.

Data Extraction

Two reviewers individually conducted the data extraction process from the included reviews. In instances of disagreement, a third reviewer was brought in to help resolve the issue. A data extraction form was created by using an Excel spreadsheet, encompassing authors' information, publication year, journal, review type (systematic review or meta-analysis), objectives, search period, databases utilized, number and type of analyzed articles, quality assessment tool used, participants' information, specifics of laser intervention, follow-up period, outcome measures, and assessment of heterogeneity.

Calculating the Actual Overlap

Since a primary study (a clinical trial) might have been presented in numerous systematic reviews, study overlap was investigated in order to reduce bias in results [25]. The actual overlap was assessed by using a visual tool known as citation matrix, along with three indices including the percentage of overlaps, covered area (CA), and corrected covered area (CCA) according to the following formulas[25]:
% Overlaps = primary studies within more than one systematic review in the umbrella review/r

$$\text{CA (covered area)} = \frac{N}{rc}$$

$$\text{CCA (corrected covered area)} = \frac{N - r}{rc - r}$$

N: Sum of primary studies published and repeated studies
r: Number of rows or primary publications
c: Number of columns or systematic reviews

The status can be investigated based on CCA: A score of 0-5 signifies mild, 6-10 signifies moderate, 11-15 signifies high, and a score greater than 15 signifies very high overlap [25].

Quality Assessment

The methodological quality of the systematic reviews was evaluated through the AMSTAR 2 tool. Two independent reviewers rated each of the 16 items on the checklist with 'yes', 'partial yes' or 'no'. Disagreements were clarified by the consultation of a third reviewer. Eventually, the online AMSTAR 2 checklist was completed and every systematic review received a quality classification of 'high', 'moderate', 'low' or 'critically low'.

Risk Of Bias Evaluation

Two reviewers utilized the ROBIS tool to evaluate the risk of bias within the selected reviews. Any discrepancies were addressed through the involvement of a third reviewer. The tool comprises three phases.[26] Phase 1 is performed to assess relevance based on the target question. Phase 2 evaluates four domains:

1. Study eligibility criteria
2. Identification and selection of studies
3. Data collection and study appraisal
4. Synthesis and findings

Within each domain, there are 5 to 6 questions, with respondents selecting from a list of potential answers: "Yes (Y)", "Probably Yes (PY)", "Probably No (PN)", "No (N)" or "No Information (NI)".

The articles were categorized into the following classifications:

- Low risk of bias: if all the signaling questions were responded with a Y/PY,
- Uncertain risk of bias: if a single question was responded with a PN/N/NI,
- High risk of bias: if multiple questions were responded with a PN/N/NI.

Phase 3 evaluates a comprehensive determination of the risk of bias using a similar structure of categorization to the phase 2 domains but with different questions.[26]

Results

Process of Literature Search

Figure 1 shows the flow diagram of PRISMA, which outlines the process of conducting the literature search. The search resulted in 4029 articles, with 1261 of them identified as duplicates and subsequently discarded. During screening titles and abstracts, 2747 studies were excluded according to the eligibility criteria while 21 were retrieved for full-text assessment. Following a thorough review of the full text, 12 studies were discarded for the following reasons: Two of them were analysis and evaluation of a previously published review,[27,28] four were literature reviews and not systematic reviews,[10,29-31] the comparison group of four studies included desensitizing agents [2,17,32,33] one was a critical summary,[34] and another one was written in the German language.[35] Finally, the present umbrella review incorporated 9 systematic reviews, out of which 6 performed a meta-analysis as well.

General Characteristics of the Systematic Reviews

A summary of the main information about the selected reviews is provided in Tables 2 and 3. The publication dates for the reviews ranged from 2011 to 2022 in these journals: *Journal of Lasers in Medical Sciences* (n = 2), *Clinical Oral Investigations* (n = 2), *Lasers in Medical Science* (n = 1), *Journal of Evidence-Based Dental Practice* (n = 1), *Cochrane Database of Systematic Reviews* (n = 1),

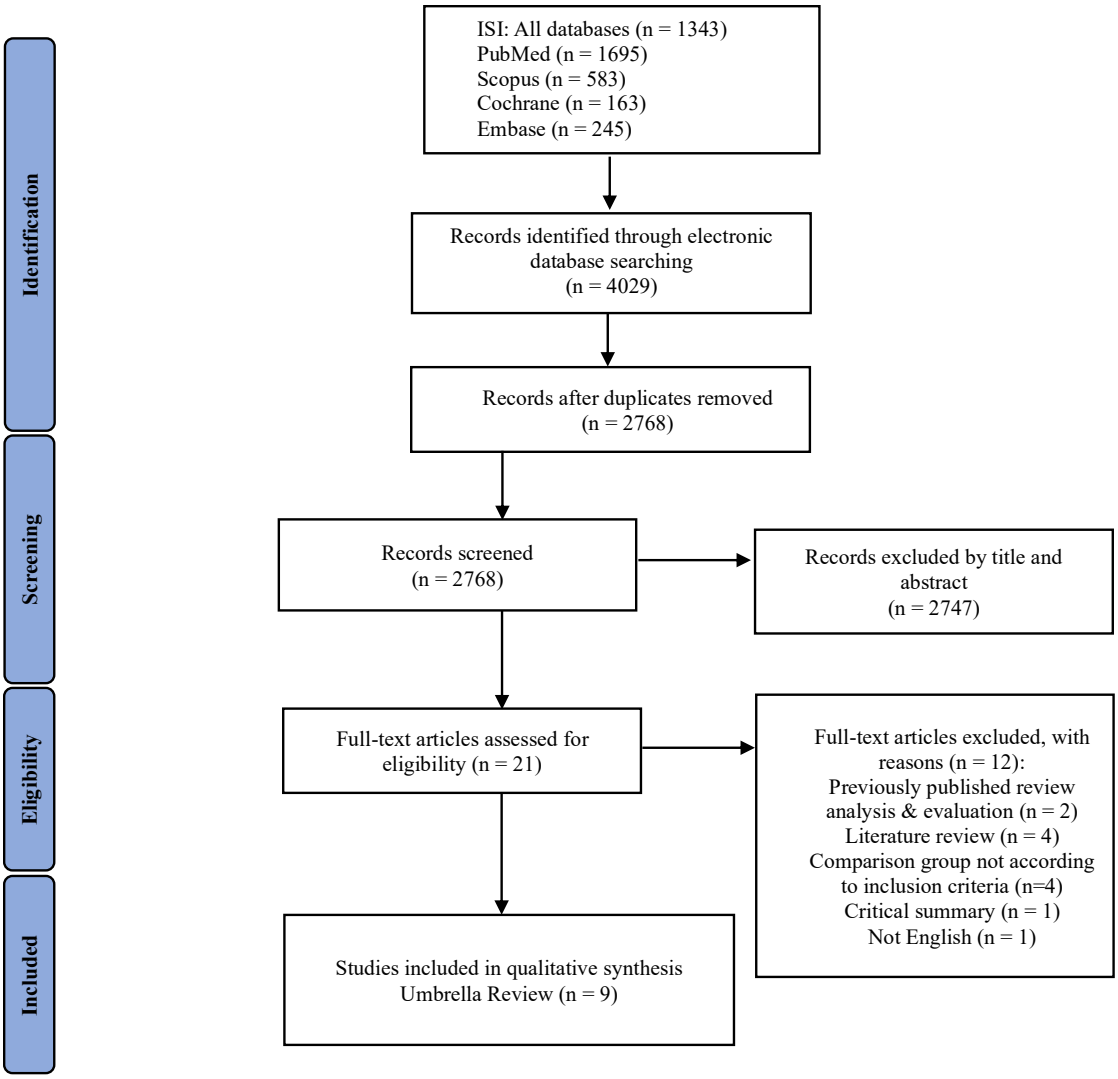

Figure 1. PRISMA Flow Diagram of the Search Process

Journal of Endodontics (n = 1), and *Journal of Dental Research* (n = 1). The databases searched by the authors included PubMed, Medline, Embase, SCOPUS, Cochrane Library, Science Direct, ISI Web of Science, Google Scholar, ProQuest, Open Grey Literature, LILACS, EBSCO, IADR, ZETOC, DARE, and CINAHL. The search period extended from inception to 2021, with each review containing between 3 and 39 primary studies. The type of lasers used in the primary studies included Diode, Er,Cr:YSGG, Er:YAG, Nd:YAG, GaALAs, low-power red laser, Infrared Low-power laser, and LED.

Overlap Calculation

According to the citation matrix (Table 4), the 9 systematic reviews are listed within columns, from the lowest to the highest based on the years. In these reviews, a total of 46 trials arranged from the lowest to the highest based on the years within rows were included. The calculations for determining the size of %Overlaps, CA, and CCA were performed based on the provided formulas:

N = 109, r = 46 c = 9

% Overlaps = 20/46 = 43.47%

$$\text{CA (covered area)} = \frac{N}{rc} = \frac{109}{46\times 9} = 0.263$$

$$\text{CCA (corrected covered area)} = \frac{N-r}{rc-r} = \frac{109-46}{(46\times 9)-46} = 0.171$$

Quality assessment

Following performing the quality assessment process using the AMSTAR 2 tool (Table 5), one systematic review was graded as 'high' quality,[4] three were graded as 'moderate' quality,[8,18,20] three as 'low' quality,[11,19,37] and two as 'critically low' quality.[7,36] The main issues associated with this aspect in most reviews include: (a) not specifying a plan for synthesis and investigating the causes of heterogeneity and not justifying deviations from their protocol (b) not mentioning the inclusion of content experts and/or grey literature in their search strategy c)

Table 2. General Characteristics of Included Reviews

Author	Publication Year	Journal	Quartile (Based on SJR)	Type of review	Objectives	Search period	Databases	Tool Used for Quality Assessment
Sgolastra et al [18]	2011	J Endod	Q1	Systematic review	To address the clinical effect of laser application compared with placebo in the treatment of DH and to survey the literature related to the safety of laser application	Until August 2010	Medline (via PubMed), Science Direct, Cochrane Clinical Trials Register, Cochrane Reviews, ISI Web of Science, LILACS & IADR	Revised recommendations of the CONSORT statement for the evaluation of randomized clinical trials
Sgolastra et al [36]	2013	J Dent Res	Q1	Systematic review & Meta-analysis	To assess the efficacy of lasers, stratified according to laser type, in changes in pain level, when compared with a placebo or no treatment and to assess the safety of the laser application and the occurrence of adverse events	Through 10 February 2013	Medline, Cochrane Controlled Clinical Trial Register, Cochrane Database of Systematic Reviews, DARE, CINAHL, Science Direct & SCOPUS	revised recommendation of the CONSORT statement
Hu et al[19]	2019	J Evid Based Dent Pract	Q1	Meta-analysis	Analyzing all the up-to-date literature on the desensitization effect of lasers to determine whether there is sufficient evidence to support their immediate and long-term effects on DH relative to the negative control	From inception up to 8 June 2018	PubMed, EMBASE, the Web of Science, CENTRAL (Cochrane Library), China National Knowledge Infrastructure & the Chinese Biomedical Literature Database	Cochrane collaboration tool & Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) tool
Rezazadeh et al[7]	2019	J Lasers Med Sci	Q3	Systematic review	To assess the efficiency of the various types of lasers used in dentistry for the prevention and treatment of DH	From January 2007 to December 2016	Medline & Scopus	Not available
Kong et al[8]	2020	Clin Oral Investig	Q1	Meta-analysis	Providing guidance for selecting an appropriate laser treatment in patients with DH, using network meta-analyses to compare different lasers, placebo, and no treatment over different time periods	From inception up to 11 December 2018	PubMed, Embase, Web of Science & CENTRAL (Cochrane Library)	Cochrane Collaboration tool in Review Manager, Funnel plots created in Stata & Grading of Recommendations Assessment, Development, and Evaluation (GRADE)
Mahdian et al [4]	2021	Cochrane Database Syst Rev	Q1	Systematic review & Meta-analysis	To assess the effects of in-office employed lasers versus placebo laser, placebo agents, or no treatment for relieving pain of DH	To 20 October 2020	Cochrane Oral Health's Trials Register, the Cochrane Central Register of Controlled Trials, MEDLINE Ovid, Embase Ovid, CINAHL EBSCO, LILACS BIREME Virtual Health Library, ISI Web of Science, ZETOC, OpenGrey	GRADE 2004
Shan et al[20]	2021	Clin Oral Investig	Q1	Systematic review & Meta-analysis	To analyse current evidence regarding the effects of LLLT on DH management	From the date of establishment until December 2020	Medline, EMBASE, PubMed, Scopus, ProQuest & the Cochrane Central Register of Controlled Trials	revised Cochrane risk-of-bias tool for randomised trials (RoB 2) & the Risk of Bias in Non-randomised Studies of Interventions (ROBINS-I) tool
Abdelkarim-Elafifi et al[37]	2022	J Lasers Med Sci	Q3	Systematic review	Describing the different parameters of 808- to 980-nm wavelength diode lasers for managing DH according to the literature and analyzing the results	From 2009 until 2020	PubMed & Cochrane	Cochrane Collaboration tool
Bellal et al[11]	2022	Lasers Med Sci	Q2	Meta-analysis	Evaluating the in vivo efficacy of near-infrared lasers in the treatment of DH compared to placebo/ no treatment	Between January 2000 and February 2021	Medline, PubMed, Cochrane, Science Direct, ProQuest, Open Grey Literature & Google Scholar	Cochrane tool

Table 3. Summary of finding of included reviews

Author	Number and type of analyzed articles	Number of participants	Type of laser intervention	Follow-up period	Outcome	Heterogeneity
Sgolastra et al[18]	3 Randomized clinical trials	56	Nd:YAG, Er:YAG and Diode GaAlAs	Minimum: 3 months	Laser treatment could reduce DH, but the reduction was not significant compared with placebo laser treatment.	Present
Sgolastra et al[36]	13 Randomized controlled clinical trials (RCTs)	437	ErYAG, ErCrYSSG, Nd:YAG and GaAlAs	From immediately to 6 months after treatment	The results seemed to support the efficacy of laser use in reducing DH, with the exception of Er,Cr:YSSG, which did not show any significant difference compared with placebo. With regard to the absence of statistical significance for the Er,Cr:YSSG vs. placebo comparison, it should be stressed that only 3 studies were included in that meta-analysis; therefore, the power to detect significant differences could have been low.	Present
Hu et al[19]	22 Randomized, controlled clinical trials	Not available	GaAlAs, Nd:YAG, Er:YAG, Er,Cr:YSSG, and diode lasers	From immediately after treatment to 6 months	All types of lasers had better immediate and long-term desensitizing effects on DH than negative controls.	Present
Rezazadeh et al[7]	39 RCTs and in vivo studies (8 studies compared laser with placebo)	Not available	Diode, Nd:YAG, GaAlAs, Er,Cr:YSGG, Er:YAG , Low-power red laser, and low-level laser-emitting toothbrush	From immediately to 6 months after treatment	Eight articles directly compared laser treatment with placebo; 6 of which reported significant reduction in tooth hypersensitivity.	Not available
Kong et al[8]	11 Randomized controlled trials (RCTs)	786	GaAlAs, Nd:YAG, Er:YAG, and Er,Cr:YSSG lasers	From immediately after treatment to 6 months	All four types of laser had significantly better effects than no treatment on DH immediately after treatment and in the long term, but there were no significant differences among the four lasers. There was a significant placebo effect, supporting the importance of including a placebo group in future studies. Er,Cr:YSGG may be the most effective laser for the treatment of DH immediately and over the long term.	Present
Mahdian et al[4]	23 Randomized controlled trials (RCTs)	936	Diode, Er,Cr:YSGG and Nd:YAG laser	short (0 to 24 hours), medium (24 hours to 2 months) and long term (more than 2 months)	The application of laser overall may improve pain intensity (VAS) when tested through air blast or tactile stimuli at short, medium, or long term.	Present
Shan et al[20]	35 Randomized controlled trials (RCTs) and non-randomized controlled studies (NRSs) (12 studies compared laser with placebo)	1351	Diode and Nd:YAG lasers	Interim follow-ups (last assessment within 1 month and up to 6 months) and persistent follow-ups (last observation at 6 months or beyond)	12 studies compared the effects of LLLT with placebo. LLLT has positive immediate, interim, and persistent DH-treatment efficacies compared with placebo.	Present
Abdelkarim-Elafifi et al[37]	11 Randomized clinical trials with or without control or placebo groups	NA	Diode lasers (808nm to 980nm)	Minimum: 30 days after treatment	A statistically significant improvement in all laser groups was described.	Present
Bellal et al[11]	6 Randomized controlled trials (RCTs)	216	Nd:YAG and Diode lasers	Minimum: 4 weeks/1 month - From immediately after treatment to 6-month post-treatment (we chose to take results at immediate and 1-month follow-up)	Near-infrared laser therapy led to statistical significant reduction in immediate and 1-month follow-up VAS scores compared to placebo/no treatment.	Present

Table 4. Citation Matrix

Review	Sgolastra et al, 2011	Sgolastra et al, 2013	Hu et al, 2019	Rezazadeh et al, 2019	Kong et al, 2020	Mahdian et al, 2021	Shan et al, 2021	Abdelkarim-Elafifi et al, 2022	Bellal et al, 2022
Number of primary studies	**3**	**13**	**22**	**8**	**11**	**23**	**12**	**11**	**6**
Gerschman et al, 1994 [38]		*	*			*			
Lier et al, 2002 [15]	*	*	*		*	*			*
Schwarz et al, 2002 [39]		*	*						
Gentile and Greghi 2004 [16]		*	*			*	*		
Birang et al, 2007 [40]	*	*	*	*	*		*		*
Lizarelli et al, 2007 [41]						*			
Aranha et al, 2009 [42]				*					
Dilsiz et al, 2009 [43]		*							
Sicilia et al, 2009 [44]		*	*				*	*	
Vieira et al, 2009 [45]	*	*	*		*	*	*		
Dilsiz et al, 2010 [12]			*	*	*		*		
Kossatz et al, 2011 [46]				*					
Orhan et al, 2011 [13]		*	*			*	*		
Won and Kim 2011 [47]			*						
Yilmaz et al, 2011a [48]		*	*	*	*	*	*	*	*
Yilmaz et al, 2011b [49]		*	*			*	*	*	*
Yilmaz et al, 2011c [50]		*	*	*	*	*			
Aranha and Eduardo 2012 [51]		*	*		*				
Mogharehabed et al, 2012 [52]							*		
Umberto et al, 2012 [53]								*	
Bao and Jing 2013 [54]			*						
Flecha et al, 2013 [55]						*			
Lund et al, 2013 [56]						*	*		
Ye et al, 2013 [57]			*						
Doshi et al, 2014 [58]						*			
Ko et al, 2014 [59]				*					
Yilmaz and Bayindir 2014 [60]			*	*	*	*			
Bal et al, 2015 [61]			*		*	*	*		*
Lee et al, 2015 [62]						*			
Moosavi et al, 2016 [63]			*						
Soares et al, 2016 [64]					*				
Suri et al, 2016 [65]						*			
Garcia et al, 2017 [66]			*			*			
Lopes et al, 2017 [67]								*	
Tevatia et al, 2017 [68]						*			
Zheng and Chen 2017 [69]			*						
Raut et al, 2018 [70]			*					*	
Tabibzadeh et al, 2018 [71]								*	
Maximiano et al, 2019 [72]					*	*	*		*
Moura et al, 2019 [73]								*	
Narayanan et al, 2019 [74]								*	
Ortiz et al, 2019 [75]						*			
Pourshahidi et al, 2019 [14]								*	
Alencar et al, 2020 [76]						*			
Naghsh et al, 2020 [77]						*		*	
Pantuzzo et al, 2020 [78]						*			

not performing data extraction in duplicate, and (d) not reporting the sources of funding for the trials involved in each review.

Items: 1. Did the research questions and inclusion criteria for the review include the components of PICO?; 2. Did the report of the review contain an explicit statement that the review methods were established prior to the conduct of the review and did the report justify any significant deviations from the protocol?; 3. Did the review authors explain their selection of the study designs for inclusion in the review?; 4. Did the review authors use a comprehensive literature search strategy?; 5. Did the review authors perform study selection in duplicate?; 6. Did the review authors perform data extraction in duplicate?; 7. Did the review authors provide a list of excluded studies and justify the exclusions?; 8. Did the review authors describe the included studies in adequate detail?; 9. Did the review authors use a satisfactory technique for assessing the risk of bias (RoB) in individual studies that were included in the review?; 10. Did the review authors report on the sources of funding for the studies included in the review?; 11. If meta-analysis was performed, did the review authors use appropriate methods for statistical combination of results?; 12. If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis?; 13. Did the review authors account for RoB in individual studies when interpreting/discussing the results of the review?; 14. Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the review?; 15. If they performed quantitative synthesis, did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review?; 16. Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?[79]

Risk of Bias Evaluation

Table 6 shows the results of the ROBIS tool for the 9 systematic reviews. In terms of eligibility criteria, all of them had a 'low' risk of bias. Six reviews were at a 'low' risk of bias with regard to the identification and selection of studies, whereas the other three were at 'unclear' or 'high' risk. The main concerns were an inadequate range of databases/electronic sources, using methods additional to database searching, and not performing the selection

Table 5. Critical Appraisal of Included Reviews Using AMSTAR 2

Authors	Items																Review Quality
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Sgolastra et al, 2011 [18]	Y	PY	Y	PY	N	N	Y	Y	Y	N	0	0	Y	Y	0	Y	Moderate quality
Sgolastra et al, 2013 [36]	Y	PY	Y	PY	Y	N	Y	Y	Y	N	Y	N	N	Y	N	Y	Critically low quality
Hu et al, 2019 [19]	Y	PY	Y	PY	Y	Y	Y	Y	Y	N	Y	N	N	N	Y	Y	Low quality
Rezazadeh et al, 2019 [7]	Y	N	Y	PY	Y	N	N	Y	N	N	0	0	N	N	0	Y	Critically low quality
Kong et al, 2020 [8]	Y	PY	Y	PY	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Moderate quality
Mahdian et al, 2021 [4]	Y	Y	Y	PY	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	High quality
Shan et al, 2021 [20]	Y	PY	Y	PY	Y	N	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Moderate quality
Abdelkarim-Elafifi et al, 2022 [37]	Y	PY	Y	PY	Y	N	PY	PY	Y	N	0	0	N	Y	0	Y	Low quality
Bellal et al, 2022 [11]	Y	Y	Y	PY	Y	Y	Y	Y	Y	N	Y	N	N	Y	Y	Y	Low quality

Table 6. Risk of Bias Evaluation Using the ROBIS Tool

Review	Phase 2				Phase 3
	1. Study Eligibility Criteria	2. Identification and Selection of Studies	3. Data Collection and Study Appraisal	4. Synthesis and Findings	Risk of Bias in the Review
Sgolastra et al, 2011[18]	+	?	-	?	+
Sgolastra et al, 2013[36]	+	+	?	?	+
Hu et al, 2019[19]	+	+	+	+	+
Rezazadeh et al, 2019[7]	+	-	-	-	?
Kong et al, 2020[8]	+	+	+	+	+
Mahdian et al, 2021[4]	+	+	+	?	+
Shan et al, 2021[20]	+	+	?	?	+
Abdelkarim-Elafifi et al, 2022[37]	+	?	?	?	+
Bellal et al, 2022[11]	+	+	?	+	+

Green cells: 'Low' risk of bias, yellow cells: 'Unclear' risk of bias, red cells: 'High' risk of bias

of studies in duplicate. Only three reviews had a 'low' risk of bias regarding data collection and study appraisal. The main concern was to avoid collecting data and assessing the risk of bias in duplicate, which might lead to errors. In terms of synthesis and findings, only three reviews had a 'low' risk of bias, mostly because of not demonstrating findings via the funnel plot or sensitivity analyses. However, all reviews except for one were classified as 'low' for the risk of bias in the review.

Principal Findings

The outcomes of the 9 systematic reviews showed that lasers reduced dentin hypersensitivity compared to placebo or no treatment immediately and in the long term. Furthermore, there was no significant difference between various types of lasers. However, heterogeneity was present in all studies except for one.[7]

Discussion

Although dentin hypersensitivity is a widely studied topic, it is still one of the painful dental conditions common in adults with low success in its treatment.[80] Laser therapy has been recommended for DH treatment,[81] but the high number of reviews published about its effectiveness leads to questionable conclusions. An umbrella review is an overview that assembles the outcomes of numerous systematic reviews into a comprehensive review in order to combine all related data.[82] It allows healthcare decision-makers to have access to evidence on treating different health conditions.[83] Thus, our umbrella review intended to analyze related systematic reviews in order to evaluate the effect of lasers in managing DH.

The overall outcome drawn from the reviews analyzed in this umbrella review was that lasers have positive effects in the treatment of dentin hypersensitivity. However, we could not make a conclusion on which type of laser is more effective. Subgroup analysis was not performed because of the existence of high heterogeneity in primary trials of systematic reviews. One systematic review concluded that Er,Cr:YSGG might be the most effective kind of laser[8] which is in contrast with another systematic review indicating no statistically meaningful difference between the Er,Cr:YSSG laser and placebo.[36] The reason could be that the three primary studies evaluating the Er,Cr:YSSG laser in these two systematic reviews were the same, but some of the other primary studies evaluating other types of lasers were different according to the citation matrix. Moreover, Kong and colleagues'[8] review was conducted in 2020, while Sgolastra and colleagues'[36] review was conducted in 2013. This means that Kong et al. included newer trials in their review.

The search strategy of the present umbrella review included the two non-invasive treatments for dentin hypersensitivity: desensitizing agents and laser therapy. Since there were many systematic reviews evaluating the impact of these two treatments on reducing dentin hypersensitivity, we decided to perform this study only on lasers and choose the reviews that included lasers as an intervention and placebo/no treatment as a comparison group. Out of the 21 full-text articles considered for eligibility, six contained desensitizing agents within their comparison groups. Three of them did not report a separate conclusion about comparing lasers with placebo/no treatment,[2,32,33] and one did not include placebo/no treatment in their comparator.[17] Therefore, these four reviews were excluded. Only two of those six could be included in this umbrella review due to performing a separate analysis for studies with a placebo comparison group.[7,20] The columns of the citation matrix for these two studies are based on the separate analysis. Therefore, only the primary studies with a placebo comparison group are included in the citation matrix in order to increase matrix accuracy (8 out of 39 trials for Rezazadeh et al.'s review and 12 out of 35 trials for Shan et al.'s review).

Study overlap status of an umbrella review should be reported in the evaluation checklist; however, until now researchers have not paid considerable attention to this matter.[25] According to the results of the citation matrix and overlap calculation of the present study, the overlap was below 50% and CCA was between 0 and 2, both indicating a mild overlap.

In order to measure the quality of methodology within the selected reviews, the AMSTAR 2 tool was utilized. Only one review was evaluated to have 'high' quality [4]. According to this tool, a high quality review contains no or one minor weakness and a correct and extensive summary of the outcomes from relevant trials is provided.[79] The results of this high quality review showed that the administration of laser might improve the visual analog scale (VAS) when the tooth is tested via tactile or air blast stimulation at short-, medium-, or long-term follow-ups [4]. One third of the systematic reviews were classified as 'moderate' quality.[8,18,20] Moderate quality indicates more than one minor weakness, and it can present a true summary of the outcomes from the relevant trials.[79] Another one third had 'low' quality.[11,19,37] A low quality review includes one crucial flaw; therefore, it might not show a correct and thorough summary of the related trials.[79] The remaining two were categorized as 'critically low' quality.[7,36] Critically low quality shows multiple crucial flaws, and relying on this review to provide a clear and complete summary of the relevant trials is not recommended.[79]

The included systematic reviews exhibit some flaws in terms of methodological quality that should be discussed. Some of them did not specify a plan for meta-analysis/synthesis or investigating the causes of heterogeneity in their protocol and did not justify deviations from their protocol. An imperfect search strategy was another concern; most reviews did not include content experts

and/or grey literature in the search process, which probably increased the publication bias. All reviews except for one performed the process of selecting studies in duplicate, but extracting data was not carried out in duplicate in most reviews. The funding sources of the studies were not reported in any of the reviews, raising the possibility of potential bias towards commercial interests. Furthermore, most reviews did not consider the risk of bias in trials while explaining results, and some failed to adequately discuss and explain the heterogeneity found in the results. However, all reviews except for one mentioned the existence of heterogeneity.

Each phase of the ROBIS tool evaluates the risk of bias according to a special matter; therefore, results may differ. It is recommended to avoid utilizing ROBIS for developing a summary quality score due to the concerns related to these kinds of scores.[26] Phase 1 showed that all the nine systematic reviews had a low risk of bias with respect to relevance because the study selection process was carried out according to inclusion/exclusion criteria and only eligible studies were selected to perform this umbrella review. Only two studies demonstrated a low risk of bias in all domains of phase 2,[8,19] whereas eight studies showed a low risk of bias within phase 3. This could be because of the different signaling questions in each phase. All reviews were at low risk of bias within the first domain of phase 2 due to their complete study eligibility criteria. Mostly found weaknesses in phase 2 were found in the remaining three domains, especially in the third and fourth. In each of the third and fourth domains, only three studies demonstrated a low risk of bias. In summary, the main concerns regarding these results include an inadequate range of databases/electronic sources or methods additional to database searching, not performing study selection, data collection or risk of bias evaluation in duplicate, and not designing a funnel plot or sensitivity analyses to demonstrate findings. The results of both reviews with a low risk of bias in all three phases support that all kinds of lasers had superior immediate and long-term desensitizing effects on dentin hypersensitivity when compared with negative controls.[8,19]

Strengths of the Umbrella Review

- Registration of a protocol in the PROSPERO database prior to conducting the present umbrella review
- Performing a literature search across five databases with high quality of evidence, using a comprehensive search strategy that obtained as many relevant studies as possible.
- Performing the steps including study selection, data extraction, AMSTAR 2 methodological quality assessment, and ROBIS risk of bias evaluation by two independent reviewers considering the assistance of another reviewer in cases of disagreement.
- Mild overlap of primary clinical trials included in systematic reviews.

Limitations of the Umbrella Review

- Some methodological weaknesses in selected systematic reviews and high heterogeneity in primary trials included in each systematic review.
- Not performing subgroup analysis owing to the heterogeneity present between primary clinical trials.

Conclusion

It can be concluded that lasers are positively effective compared to placebo/no treatment in treating dentin hypersensitivity. Most systematic reviews that were included in this umbrella review showed that lasers are effective both immediately after the treatment and in the long term. Furthermore, there was no significant difference between various types of lasers. However, heterogeneity was high in the studies.

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Competing Interests

It is declared by the authors that there are no conflicts of interest regarding this study.

Ethical Approval

Not applicable.

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