©Operative Dentistry, 2020, **45-6**, 589-597

Literature Review

Laser Influence on Dental Sensitivity Compared to Other Light Sources Used During In-office Dental Bleaching: Systematic Review and Meta-analysis

BGS Casado • EP Pellizzer • JR Souto Maior • CAA Lemos • BCE Vasconcelos • SLD Moraes

Clinical Relevance

The use of laser light during bleaching will not reduce the incidence or severity of sensitivity and will not increase the degree of color change compared with nonlaser light sources.

SUMMARY

Objective: To evaluate whether the use of laser during in-office bleaching promotes a reduction in dental sensitivity after bleaching compared with other light sources.

Methods: The present review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) and is registered with PROSPERO (CDR42018096591). Searches were conducted in the PubMed/Medline, Web of Science, and Cochrane Library databases for relevant articles published up to August 2018. Only randomized clinical trials among adults that compared the use of laser during in-office whitening and other light sources were considered eligible.

Results: After analysis of the texts retrieved during the database search, six articles met the eligibility criteria and were selected for the present review. For the outcome dental sensitivity, no significant difference was found favoring any type of light either for intensity

*Bruno Gustavo da Silva Casado, PhD, DDS, adjunct professor, Dentistry School, University of Pernambuco, Recife, Brazil

Eduardo Piza Pellizzer, PhD, DDS, full professor, Araçatuba Dental School, São Paulo State University (UNESP). Araçatuba, Brazil

Juliana Raposo Souto Maior, PhD, DDS, Dentistry School, University of Pernambuco, Recife, Brazil

Cleidiel Aparecido Araújo Lemos, PhD, DDS, Araçatuba Dental School, São Paulo State University (UNESP). Araçatuba, Brazil

Belmiro Cavalcanti do Egito Vasconcelos, PhD, DDS, associate professor, Dentistry School, University of Pernambuco, Recife, Brazil

Sandra Lucia Dantas de Moraes, PhD, DDS, adjunct professor, Dentistry School, University of Pernambuco, Recife, Brazil

*Corresponding author: Av General Newton Cavalcanti, 1650, Tabatinga, Camaragibe-PE, Brazil, 54.756-220; e-mail: brunocasado@hotmail.com

https://doi.org/10.2341/19-064-L

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-09-01 via free access

(mean difference [MD]: –1.60; confidence interval [CI]: –3.42 to 0.22; p=0.09) or incidence (MD: 1.00; CI: 0.755 to 1.33; p=1.00). Regarding change in tooth color, no significant differences were found between the use of the laser and other light sources (MD: –2.22; CI: –6.36 to 1.93; p=0.29).

Conclusions: Within the limitations of the present study, laser exerts no influence on tooth sensitivity compared with other light sources when used during in-office bleaching. The included studies demonstrated that laser use during in-office bleaching may have no influence on tooth color change.

INTRODUCTION

Tooth whitening is one of the most common cosmetic procedures performed in dental offices due to the fact that this conservative, easy-to-execute method offers fast results.[1-3] Among the different forms of treatment available for bleaching vital teeth, the in-office method is an alternative.[4] This clinical method involves the direct supervision by a dental professional throughout the application of the bleaching agent (hydrogen peroxide) to the dental surfaces.[2,3,5,6]

Hydrogen peroxide serves as a strong oxidizing agent, leading to the formation of free radicals.[5] These free radicals attack complex pigment molecules, resulting in smaller, colorless by-products that establish the whitening effect seen in the enamel.[1,7-9]

In the attempt to enhance the bleaching effect, many manufacturers recommend the use of light or heat for the catalytic decomposition of the peroxides.[1,6,10] Several sources of light proposed for this purpose include lasers, light-emitting diodes (LEDs), plasma arc lamps, and halogen lamps.[6,11,12] However, this practice is risky as studies show that the use of light sources can have side effects, such as tooth sensitivity, due to the increase in intrapulpal temperature and the influx of free radicals from the hydrogen peroxide, which can penetrate the dental structure and reach the pulp.[13-15]

On the other hand, some authors report that the use of laser in combination with in-office bleaching agents is recommended as an adequate strategy to reduce dental sensitivity after office bleaching as this source emits well-defined monochromatic light at a single wavelength, thereby reducing the risk of increasing intrapulpal temperature.[16-18] Laser has also been claimed to have analgesic properties.[19]

Thus, the aim of the present systematic review and meta-analysis was to evaluate whether the use of a laser during in-office dental bleaching promotes a reduction in tooth sensitivity after bleaching compared with other light sources. The hypothesis was that the application of laser during in-office dental bleaching reduces tooth sensitivity after bleaching.

METHODS

Registration Protocol

The present systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA statement).[20] The methods used for this systematic review have been registered with PROSPERO (CDR42018096591).

Eligibility Criteria

A specific question was developed based on the PICO (population, intervention, control, and outcomes) criterion. The following was the guiding question: Does the use of laser during in-office dental bleaching promote a reduction in tooth sensitivity and color change compared with other light sources? The population was composed of patients receiving in-office bleaching using a light source; the intervention was in-office bleaching combined with the use of the laser, and the control was in-office bleaching with other light sources (LED, halogen light, and plasma arc lamps). The primary outcome was tooth sensitivity after bleaching, and the secondary outcome was the change in color.

Prospective randomized clinical trials published in the English language that had at least 10 patients and made a direct comparison between the use of laser during in-office whitening and other light sources were considered eligible. Retrospective studies, crossover studies, *in vitro* studies, *in situ* studies, animal studies, mechanical studies, case reports and reviews of the literature were excluded.

Search Methods and Search Strategy

Two independent reviewers (BGSC and CAAL) performed searches in the Cochrane Library, Pubmed/MEDLINE, and Web of Science databases for relevant articles published up to August 2018. The following search terms were used: "dental bleaching and light OR tooth bleaching and light OR teeth bleaching and light OR dental whitening and light OR tooth whitening and light OR teeth whitening and light."

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-09-01 via free access

The first phase of the selection process involved an analysis of the titles and abstracts retrieved during the search of the electronic databases. For studies in which it was not possible to obtain sufficient information, the complete article was obtained. The two researchers also performed a manual search for articles published up to August 2018 in specific journals in the field: *Dental Materials*, *Journal of Dentistry*, *Operative Dentistry*, and *Clinical Oral Investigations*. A manual search of the OpenGrey database (www.opengrey.eu) was also conducted to determine relevant articles in the grey literature. A third reviewer (JRSM) examined all the divergences of opinion between the two reviewers regarding the selection of articles, and a consensus was reached through discussion.

Risk of Bias and Evaluation of Study Quality

Two reviewers (BGSC and CAAL) evaluated the methodologic quality of the studies included in the review. For such, the Cochrane criteria were used to appraise the quality and risk of bias based on sequence generation, allocation concealment, blinding of participants, personnel or outcome investigator, incomplete outcome data, selective outcome reporting, and other sources of bias. Using the Cochrane system, the risk of bias is classified as low, high, or unclear.

Data Extraction

Data were extracted by one of the reviewers (BGSC) to tabulate data of greater relevance to the analysis of the studies. The following data were extracted: author/year, type of study, patients, type of light used, bleaching agent/concentration, tooth sensitivity, and tooth discoloration.

Meta-analysis

The meta-analysis was based on the Mantel-Haenzel and the inverse variance methods using Review Manager 5 (Cochrane Group, Haymarket, London, United Kingdom). The dichotomous outcome (absolute risk of tooth sensitivity) was evaluated using the risk ratio, and continuous outcomes (intensity of tooth sensitivity, subjective and objective color change) were evaluated based on the mean difference. A p-value <0.05 was considered indicative of statistical significance. Heterogeneity was evaluated based on the I^2 value (25%=low, 50%=moderate, and 75%=high). When heterogeneity was statistically significant ($p<0.10$), a random-effects model was used for the meta-analysis; otherwise, a fixed-effects model was used.[21]

Additional Analysis

An additional analysis was performed using the Kappa coefficient to establish interexaminer agreement in the selection process of the studies from the three databases. The Kappa value was obtained by evaluating the titles and abstracts selected. High levels of agreement were found for the Cochrane Library (K=0.86), PubMed/MEDLINE (K=0.88), and Web of Science (K=0.80) databases.

RESULTS

The search of the databases led to the retrieval of 1301 articles: 763 from PubMed/MEDLINE, 395 from Web of Science, and 143 from the Cochrane Library. After duplicates were removed, 995 titles and abstracts were analyzed based on the eligibility criteria. Ten studies were preselected for full-text analysis, of which four were excluded for the following reasons: literature review, failure to use the laser as a light source, and failure to compare laser to other light sources. Details on the search strategy are presented in the flowchart (Figure 1).

Six studies were selected for data analysis and are listed in detail in Table 1. All studies were randomized controlled trials, one of which had a split-mouth design. A total of 136 patients were included in the studies. Sample sizes ranged from 16 to 40 individuals age 18 to 70 years. In all studies, hydrogen peroxide was the in-office bleaching agent used, with a concentration of 35% in three studies, 37% in one study, and 38% in two studies. Evaluations of dental sensitivity were performed in all studies. Four studies evaluated the incidence of sensitivity and three evaluated intensity using the visual analog scale. In four studies, the change in tooth color was evaluated subjectively using a color scale.

Risk of Bias

Each trial was assessed for risk of bias; the scores are displayed in Figure 2. A low risk of bias was found regarding participant blinding, staff assessment and results, incomplete outcome, and selective reporting items. However, all studies[22-27] had unclear bias regarding the random sequence generation and allocation concealment.

Meta-analysis

Tooth Sensitivity—Dental sensitivity was evaluated in two ways: intensity and incidence. Intensity was determined when the patient quantified his or her response to pain on a visual analog scale, while

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-09-01 via free access

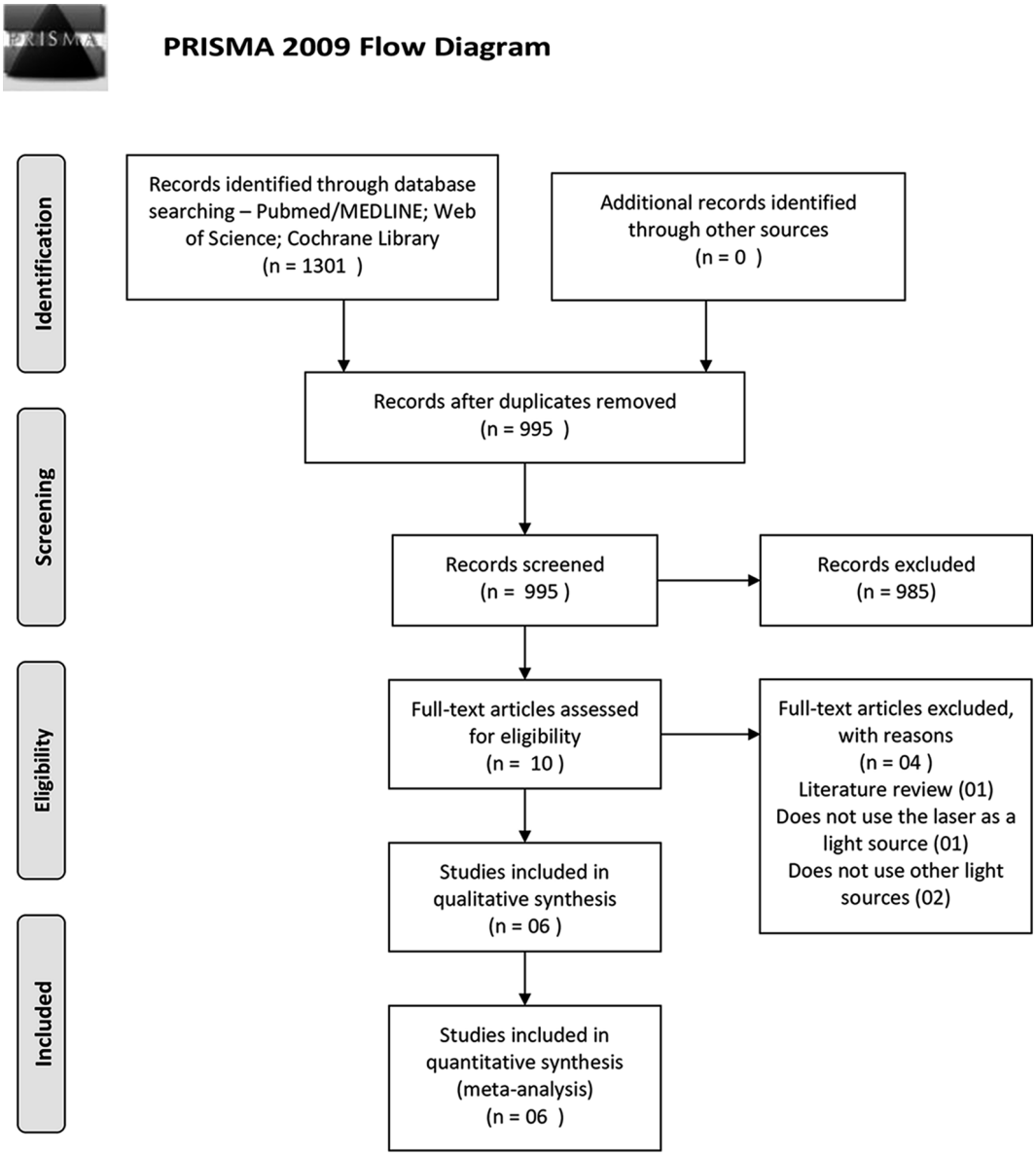


Figure 1. *Flowchart showing steps of article selection process.*

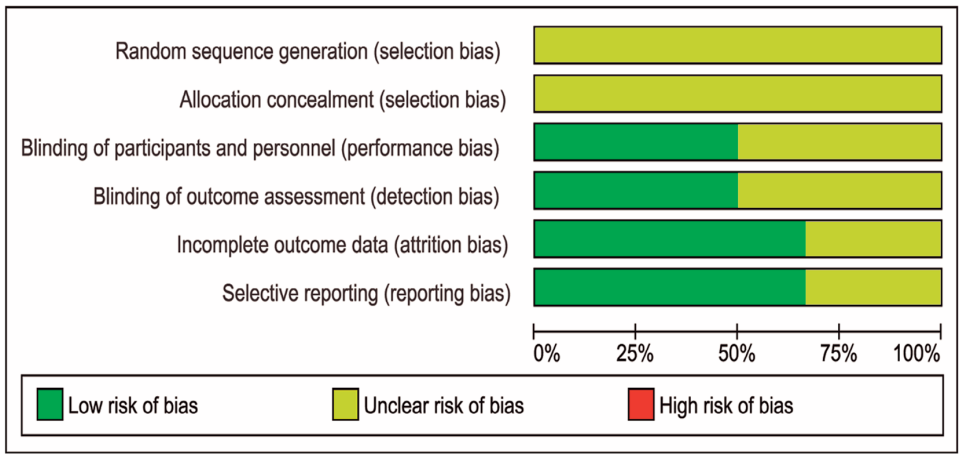


Figure 2. *Cochrane scale for bias risk.*

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-09-01 via free access

Table 1: *Summary of Characteristics of Included Studies*

Author, Date	Study	Sample Size	Sex	Light Source (N)	Bleaching Agent	Light Source Time per Session	Tooth Sensitivity		Color Change	
							Intensity	Incidence	Subjective Shade Evaluation	Objective Shade Evaluation
Marson and others, 2008[22]	RCT	30	NR	Halogen light (10)	35% HP	NR	NR	5 (10)	NR	NR
				LED (10)			NR	8 (10)		
				LED/Laser (10)			NR	6 (10)		
Gurgan and others, 2010[23]	RCT	30	M: 11 (27.5%) F: 29 (72.5%)	LED (10)	38% HP	1st 20′ 2nd 20′	2.9±1.48	NR	8.5±3.59	5.43±0.201
				Laser (10)	37% HP	1st 7 × 15″ 2nd 4 × 15″ 3rd 4 × 15″	0.59±0.92	NR	8.6±3.19	5.59±0.172
				PAC (10)		1st 7′ 2nd 7′ 3rd 7′	3.8±1.29	NR	8.4±2.98	5.28±0.096
de Almeida and others, 2012[24,25]	RCT	20	NR	Halogen light (10)	35% HP	1st 20” 2nd 20” 3rd 20”	2.98±2.97	10 (10)	1.1±0.31	NR
				LED/laser (10)		1st 3′ 2nd 3′ 3rd 3′	2.2±3.22	10 (10)	1.0±0.1	NR
Polydorou, and others 2013[26]	RCT	40	NR	Halogen light (10)	38% HP	1st 30” 2nd 30” 3rd 30” 4th 30”	NR	NR	5.5±2.94	6.1±1.9
				Laser (10)		1st 8′ 2nd 8′ 3rd 8′ 4th 8′	NR	NR	1.15±1.7	2.15±2.4
Farhat and others, 2014[27]	RCT (SM)	16	NR	LED (16)	35% HP	1st 3′ 2nd 3′ 3rd 3′	0.61±1.17	6 (16)	2.75±1.53	NR
				LED/laser (16)			0.75±1.2	7 (16)	2.63±1.02	NR

Abbreviations: F, female; HP, hydrogen peroxide; LED, light-emitting diode; M, male; NR, not reported; PAC, plasma arc lamp; RCT, randomized controlled trial; SM, split mouth.

incidence was assessed by the number of sensitivity events.

The intensity of dental sensitivity was measured using the visual analog scale (continuous outcome) in three studies. The random-effects model revealed no significant difference favoring any type of light (mean difference [MD]: –1.60; confidence interval [CI]: –3.42 to –0.22; $p=0.09$). Moreover, laser did not lead to significantly lower dental sensitivity compared with the other light systems (Figure 3). However, the data were heterogeneous (χ^2: 29.39; $I^2=90\%$; $p<0.0001$) and the studies included in the analysis did not share a common effect size.

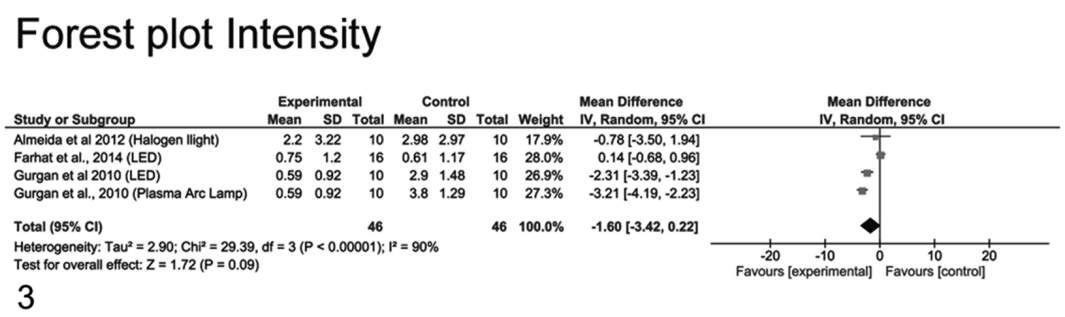
The incidence of dental sensitivity among the light systems combined with the in-office bleaching based on visual analog scale scores was evaluated in three studies. The relative risks revealed no differences between laser and the other light sources (MD: 1.00; CI: 0.755 to 1.33, $p=1.00$). Heterogeneity was nonsignificant (Figure 4), and all studies included in the analysis shared a common effect size, suggesting no differences in the incidence of dental sensitivity among the light sources used.

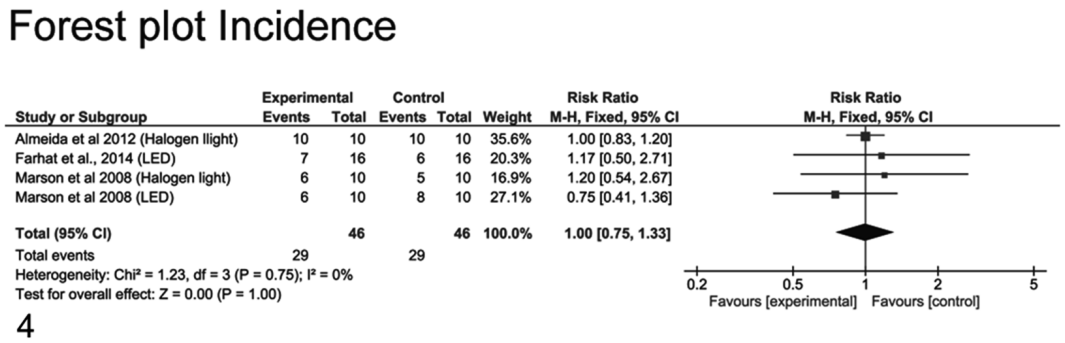
Color Change—The effectiveness of whitening was determined in three studies using the subjective method (Vita Classical shade guide) immediately after dental whitening. The random-effects model revealed no significant differences between the use of laser and other light sources combined with in-office dental bleaching (MD: –2.22; CI: –6.36 to 1.93; $p=0.29$). The data were heterogeneous (χ^2: 30.60; $I^2=97\%$; $p<0.00001$) (Figure 5), and the studies included in the analysis did not share a common effect size.

DISCUSSION

In the present systematic review and meta-analysis, no significant differences were found in the reduction of dental sensitivity (intensity or incidence) or the change in tooth color when the use of the laser was compared with other light sources (LED, halogen light, and plasma arc lamps) during in-

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-09-01 via free access





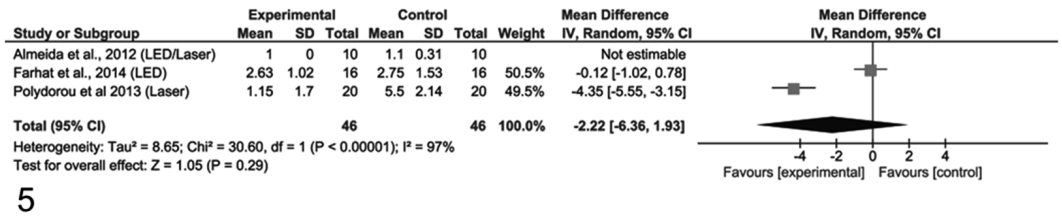


Figure 3. *Forest plot for the event "sensitivity intensity."*

Figure 4. *Forest plot for the event "sensitivity incidence."*

Figure 5. *Forest plot for the event "color change."*

office dental bleaching. Therefore, the initial hypothesis of the study was rejected, which is in agreement with the findings of previous studies.[22,26,27]

Sensitivity after in-office bleaching procedures is directly related to the type and concentration of the bleaching agent, contact time of the bleaching agent with the tooth structure, and photothermal effect of the light source used in a way that is compatible with the application of the bleaching gel. Tooth sensitivity was assessed after bleaching treatment in most of the studies included in the present review.[22-24,27]

Although the literature reports that laser has anti-inflammatory and analgesic effects,[28] no reduction in sensitivity was found when this light source was used. This result may be explained by the fact that the laser does not come into direct contact with the pulp. Moreover, the layer formed by the bleaching gel, which has pigments, can minimize the energy density on the target tissue and cause the reflection of light, which significantly reduces the absorption of the laser by the dental pulp. This means that the therapeutic action of the laser may be reduced, resulting in no positive effect on tooth sensitivity.[9,27,29,30]

Since no beneficial effects on tooth sensitivity have been found, the use of light sources during the whitening process should be viewed with caution. These sources have a photothermal effect on the bleaching agent, and the conversion of light energy

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-09-01 via free access

into heat can lead to an uncontrolled increase in intrapulpal temperature.[9] According to Lima and others,[31] a 5°C increase in temperature is harmful to the pulp.

Another possible explanation for the lack of a significant difference in sensitivity (both intensity and incidence) after bleaching with the use of laser compared with other light sources is that most of the studies evaluated[22,24,27] used a hybrid device that combined three blue LED outputs and three low-level infrared laser outputs. This hybridization of light sources can prevent the laser light from being collimated, so that it does not reach the target tissue adequately to provide any beneficial effects regarding a reduction in tooth sensitivity.[27]

Another benefit often expected when using light sources during bleaching is the enhancement of the change in tooth color. Therefore, this was an outcome evaluated in the present review. Despite being widely used,[23] a subjective color analysis is complex because the distinction of color can vary from individual to individual and is influenced by both environmental and physical factors, such as the size, shape, and position of the teeth; ambient light; and background color.[1,5] In the clinical studies included in the meta-analysis for this outcome,[25-27] the results were based on a subjective assessment using a color scale.

No statistically significant difference in the subjective color assessment was found when the use of the laser was compared to LED or halogen light. This result is in agreement with data reported in recent studies[2,3,9,15,32] in which light activation during in-office bleaching was found to exert no influence on the change in tooth color. As the change in color is directly related to the bleaching agent used, its concentration, and contact time with the dental surface, this may explain the lack of significant differences among the light sources evaluated.[2,3]

Although the influence of laser and other light sources is being investigated throughout the world, several characteristics of the studies limit the discussion. In addition, these results should be interpreted with caution given that for the four studies included in the meta-analysis the mean scores for pain in the control group were low. Having low values in the control group may make it difficult to resolve the effect of the treatment studied. Although all studies included in the present systematic review were randomized clinical trials, the large diversity of protocols regarding the application of the light source and whitening gel as well as the concentration of these agents prevent the direct comparison of results. Further studies with standardized protocols are required as well as studies that use precise, objective color and sensitivity assessment methods to reduce the potential influence of bias.

CONCLUSIONS

Within the limitations of this study, the evidence in this systematic review and meta-analysis suggests that laser exerts no influence on tooth sensitivity compared with other light sources when used during in-office dental bleaching. The included studies demonstrated that laser use during in-office bleaching may have no influence on the degree of tooth color change.

Acknowledgements

The first author was granted a PhD degree scholarship from the Coordination for the Improvement of Higher Education Personnel (CAPES - Brasil). The authors Eduardo Piza Pellizer and Belmiro Cavalcanti do Egito Vasconcelos received grants from the National Council for Scientific and Technological Development (CNPq), Ministry of Science and Technology, Brazil.

Conflict of interest

The authors of this manuscript certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

(Accepted 25 July 2019)

REFERENCES

1. Kiomars N, Azarpour P, Mirzaei M, Kamangar SSH, Kharazifard MJ, & Chiniforush N (2016) Evaluation of the diode laser (810nm, 980nm) on color change of teeth after external bleaching *Laser Therapy* **25(4)** 267-272.
2. Maran BM, Burey A, de Paris Matos T, Loguercio AD, & Reis A (2018) In-office dental bleaching with light vs. without light: A systematic review and meta-analysis *Journal of Dentistry* **70** 1-13. http://dx.doi.org/10.1038/sj.bdj.2018.331
3. SoutoMaior JR, de Moraes SLD, Lemos CAA, Vasconcelos BCE, Montes MAJR, & Pellizzer EP (2018) Effectiveness of light sources on in-office dental bleaching: A systematic review and meta-analyses *Operative Dentistry* **14(3)** E105-E117. http://dx.doi.org/10.2341/17-280-L
4. Alomari Q & El Daraa E (2010) A randomized clinical trial of in-office dental bleaching with or without light activation *Journal of Contemporary Dental Practice* **11(1)** 17-24.
5. Mena-Serrano AP, Garcia E, Luque-Martinez I, Grande R, Loguercio AD, & Reis A (2016) A single-bling randomized trial about the effect of hydrogen peroxide

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-09-01 via free access

concentration on light-activated bleaching *Operative Dentistry* **41(5)** 455-464. doi: http://dx.doi.org/10.2341/15-077-C

6. Shahabi S, Assadian H, Nahavandi AM, & Nokhbatolfoghahaei H (2018) Comparison of tooth color change after bleaching with conventional and different light-activated methods *Journal of Lasers in Medical Sciences* **9(1)** 27-31. http://dx.doi.org/10.15171/jlms.2018.07
7. Kawamoto K & Tsujimoto Y (2004) Effects of the hydroxyl radical and hydrogen peroxide on tooth bleaching *Journal of Endodontics* **30(1)** 45-50. http://dx.doi.org/10.1097/00004770-200401000-00010
8. Eimar H, Siciliano R, Abdallah MN, Nader SA, Amin WM, Martinez PP, Celemin A, Ceruti M, & Tamimi F (2012) Hydrogen peroxide whitens teeth by oxidizing the organic structure *Journal of Dentistry* **40(Supplement 2)** 25-33. http://dx.doi.org/10.1016/j.jdent.2012.08.008
9. Mondelli RFL, Azevedo JFDG, Francisconi AC, Almeida CM, & Ishikiriama SK (2012) Comparative clinical study of the effectiveness of different dental bleaching methods—Two year follow-up *Journal of Applied Oral Science* **20(4)** 435-443.
10. Loiola ABA, Souza-Gabriel AE, Scatolin RS, & Corona SAM (2016) Impact of hydrogen peroxide activated by lighting-emitting diode/laser system on enamel color and microhardness: An *in situ* design *Contemporary Clinical Dentistry* **7(3)** 312-316. http://dx.doi.org/10.4103/0976-237X.188544
11. Buchalla W & Attin T (2007) External bleaching therapy with activation by heat, light or laser —A systematic review *Dental Materials* **23(5)** 586-596.
12. de Freitas PM, Menezes AN, da Mota AC, Simoes A, Mendes FM, Lago AD, Ferreira LS, & Ramos-Oliveira TM (2016) Does the hybrid light source (LED/Laser) influence temperature variation on the enamel surface during 35% hydrogen peroxide bleaching? A randomized clinical trial *Quintessence International* **47(1)** 61-73. http://dx.doi.org/10.3290/j.qi.a34454
13. Ontiveros JC & Paravina RD (2009) Color change of vital teeth exposed to bleaching performed with and without supplementary light *Journal of Dentistry* **37(11)** 840-847.
14. Kugel G, Ferreira S, Sharma S, Barker ML, & Gerlach RW (2009) Clinical trial assessing light enhancement of in-office tooth whitening *Journal of Esthetic and Restorative Dentistry* **21(5)** 336-347. http://dx.doi.org/10.1111/j.1708-8284.2009.00287.x
15. Kossatz S, Dalanhol AP, Cunha T, Loguercio A, & Reis A (2011) Effect of light activation on tooth sensitivity after in-office bleaching *Operative Dentistry* **36(3)** 251-257. http://dx.doi.org/10.2341/10-289-C
16. Baik JW, Rueggeberg FA, & Liewehr FR (2001) Effect of light-enhanced bleaching on in vitro surface and intrapulpal temperature rise *Journal of Esthetic and Restorative Dentistry* **13(6)** 370-378.
17. Dantas CM, Vivan CL, Ferreira LS, Freitas PM, & Marques MM (2010) In vitro effect of low intensity laser on the cytotoxicity produced by substances released by bleaching gel *Brazilian Oral Research* **24(4)** 460-466.
18. Moosavi H, Arjmand N, Ahrari F, Zakeri M, & Maleknejad F (2016) Effect of low-level laser therapy on tooth sensitivity induced by in-office bleaching *Lasers in Medical Science* **31(4)** 713-719. http://dx.doi.org/10.1007/s10103-016-1913-z
19. Mezawa S, Iwata K, Naito K, & Kamogawa H (1988) The possible analgesic effect of soft-laser irradiation on heat nociceptors in the cat tongue *Archives Oral Biology* **33(9)** 426 693-694.
20. Moher D, Liberati A, Tetzlaff J, Altman DG, & Group P (2010) Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement International Journal of Surgery **8(5)** 336-341.
21. Egger MSG & Altman DG (eds) (2003) Principles of and procedures of systematic reviews In: Egger MSG (ed) *Systematic Reviews in Health Care: Meta-Analysis in Context* BMJ Books, London, United Kingdom 23-42.
22. Marson FC, Sensi LG, Vieira LCC, & Araujo E (2008) Clinical evaluation of in-office dental bleaching treatments with and without the use of light-activation sources *Operative Dentistry* **33(1)** 15-22.
23. Gurgan S, Cakir FY, & Yazici E (2010) Different light-activated in-office bleaching systems: A clinical evaluation *Lasers in Medical Science* **25(6)** 817-822. http://dx.doi.org/10.1007/s10103-009-0688-x
24. de Almeida LCAG, Costa CAS, Riehl H, dos Santos PH, Sundfeld RH, & Briso ALF (2012) Occurrence of sensitivity during at-home and in-office tooth bleaching therapies with or without use of light sources *Acta Odontologica Latinoamericana* **25(1)** 3-8.
25. de Almeida LCAG, Riehl H, dos Santos PH, Sundfeld MLMM, & Briso ALF (2012) Clinical evaluation of the effectiveness of different bleaching therapies in vital teeth *International Journal of Periodontics and Restorative Dentistry* **32(3)** 303-309.
26. Polydorou O, Wirsching M, Wokewitz M, & Hahn P (2013) Three-month evaluation of vital tooth bleaching using light units—A randomized clinical study *Operative Dentistry* **38(1)** 21-32.
27. Fahart PBA, Santos FA, Gomes JC, & Gomes OMM (2014) Evaluation of the efficacy of LED-laser treatment and control of tooth sensitivity during in-office bleaching procedures *Photomedicine and Laser Surgery* **32(7)** 422-426. http://dx.doi.org/10.1089/pho.2014.3729
28. Kabbach W, Zezell DM, Bandeca MC, Pereira TM, & Andrade MF (2010) An in vitro thermal analysis during different light-activated hydrogen peroxide bleaching *Laser Physics* **20(9)** 1833-1837.
29. Fornaini C, Lagori G, Merigo E, Meleti M, Mandredi M, Guidotti R, Serraj A, & Vescovi P (2013) Analysis of shade, temperature and hydrogen peroxide concentration during dental bleaching: in vitro study with the KTP and diode lasers *Lasers in Medical Science* **28(1)** 1-6. https://doi.org/10.1007/s10103-011-1037-4
30. Klaric E, Rakic M, Sever I, & Tarle Z (2015) Temperature rise during experimental light-activated bleaching *Lasers in Medical Science* **30(2)** 567-576. http://dx.doi.org/10.107/s10103-013-1366-6

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-09-01 via free access

31. Lima AF, Ribeiro AP, Basso FG, Bagnato VS, Hebling J, Marchi GM, & de Souza Costa CA (2014) Effect of low-level laser therapy on odontoblast-like cells exposed to bleaching agent *Lasers in Medical Science* **29(5)** 1533-1538. http://dx.doi.org/10.1007/s10103-013-1309-2

32. Bernardon JK, Sartori N, Ballarin A, Perdigao J, Lopes GC, & Baratieri LN (2010) Clinical performance of vital bleaching techniques *Operative Dentistry* **35(1)** 3-10. http://dx.doi.org/10.2341/09-008CR

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-09-01 via free access