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Evaluation of Tooth Sensitivity During In-Office Bleaching with Laser Irradiation: A Systematic Review and Meta-Analysis

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Abstract

Introduction: This systematic review and meta-analysis aimed to evaluate the impact of laser irradiation during in-office bleaching on tooth sensitivity.

Methods: A comprehensive search was conducted in PubMed, Scopus, and Web of Science for randomized controlled trials (RCTs) published up to August 2025 that assessed tooth sensitivity following laser-assisted in-office bleaching. The primary outcome was sensitivity intensity, measured using the Visual Analog Scale (VAS). A total of 230 records were retrieved, 31 full-texts were assessed, and 4 RCTs were included in the final analysis. Data were extracted, and meta-analyses were performed using a random-effects model.

Results: Four RCTs were included. All included studies used diode lasers (wavelengths: 810–980 nm). The meta-analysis demonstrated a significant reduction in post-bleaching tooth sensitivity with laser irradiation compared to the control group (WMD = 1.174; 95% CI: 0.474 to 1.874; $P = 0.001$). However, high heterogeneity was observed ($I^2 = 99.93\%$). Sensitivity analyses confirmed the robustness of the findings, though potential publication bias was suggested.

Conclusion: Laser irradiation during in-office bleaching appears to significantly reduce tooth sensitivity compared to conventional methods, potentially improving patient comfort. Nonetheless, the high variability among studies highlights the need for further well-designed clinical trials with standardized protocols to confirm these results and optimize laser parameters.

Keywords: Tooth Bleaching, Laser, Tooth Sensitivity

Introduction

Nowadays, dental treatments such as veneers, crowns, and bleaching are commonly used to improve tooth discoloration and meet patients' aesthetic needs. Bleaching is considered the least invasive approach for treating discolored teeth.[1] Home bleaching and in-office bleaching are the two primary professional teeth whitening methods that differ in the concentration of the bleaching agent and the duration of treatment.

The bleaching process works by releasing active oxygen molecules from the bleaching agent, which then oxidize the chromogens in both enamel and dentin.[2] According to a recent study, hydrogen peroxide and its byproducts can easily penetrate these layers, reaching the pulp tissue and causing inflammation.[3]

The exact cause of tooth sensitivity following bleaching remains unclear. However, the primary hypothesis is that hydrogen peroxide byproducts not only remove stains from the tooth surface but also mildly demineralize it, making the surface more porous and increasing tooth sensitivity[4] .Additionally, it is claimed that bleaching agents are believed to deeply penetrate the tooth, leading to temporary pulp irritation and an increase in interstitial fluid[5] .Studies show that between 65% to 85% of individuals undergoing in-office whitening, which uses a high concentration of hydrogen peroxide either alone or in combination with light-activating sources, experience tooth sensitivity.[6-7] To accelerate the whitening process, various light sources , such as plasma arcs, light-emitting diodes (LEDs), quartz-tungsten-halogen lamps, and different types of lasers, are utilized.[8] Light generates heat, which speeds up hydrogen peroxide decomposition, producing free oxygen radicals that enhance stain removal. Although heat improves bleaching efficiency, it may also increase post-treatment tooth sensitivity.[9]

The use of high-power lasers, such as diode and Nd:YAG lasers, during in-office bleaching can be beneficial. These lasers enhance the bleaching effect by accelerating the breakdown of hydrogen peroxide, as part of the bleaching gel absorbs the laser energy, which activates the gel and speeds up the whitening process. However, not all of the laser energy is absorbed by the gel; some of it reaches the

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underlying dental tissues. When this residual energy is distributed across multiple teeth, the energy absorbed by each tooth is reduced, potentially falling within the therapeutic range of low-level laser therapy (LLLT). As a result, this residual energy may have analgesic and anti-inflammatory effects, reducing the likelihood and severity of post-bleaching tooth sensitivity.

The intensity of tooth sensitivity in in-office bleaching depends on several factors, including the patient's pain threshold, the concentration of the bleaching gel, and the type of light source used.[10]

Low-level laser therapy (LLLT) is a light-based treatment that can have analgesic and anti-inflammatory effects during bleaching treatment. Since this monochromatic light source emits a specific wavelength, it reduces the risk of pulpal temperature increase. Additionally, low-power lasers can interact with the dental pulp, leading to an increase in odontoblastic activity, which in turn promotes the production of tertiary dentin and reduces the diameter of dentinal tubules.

These key properties indicate that LLLT can help minimize pulpal damage and inflammation caused by in-office bleaching and reduce tooth sensitivity.[11-14]

Despite numerous studies investigating the effects of in-office bleaching and laser applications, a consensus on the clinical efficacy of lasers in reducing post-bleaching sensitivity has remained lacking.

Existing research often suffers from methodological heterogeneity, small sample sizes, and variability in laser parameters (e.g., wavelength, power settings, and exposure duration). Additionally, few meta-analyses have quantitatively assessed the overall impact of lasers on tooth sensitivity during bleaching.

This review aimed to bridge these gaps by systematically synthesizing the available evidence and offering clinical insights into the potential role of laser irradiation as a pain-reducing modality in professional teeth whitening.

It was hypothesized that the application of laser during in-office bleaching significantly reduced tooth sensitivity by promoting anti-inflammatory and analgesic effects, modulating odontoblastic activity, and enhancing tertiary dentin formation.

This systematic review and meta-analysis aimed to comprehensively evaluate the effectiveness of laser irradiation in reducing tooth sensitivity during in-office bleaching.

By synthesizing existing evidence, this study sought to determine whether laser irradiation served as a reliable adjunctive technique for minimizing bleaching discomfort and improving patient outcomes.

Methods

Eligibility criteria

This study was designed and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, with prior registration in the International Prospective Register of Systematic Reviews (PROSPERO) database (CRD42022303160).

This meta-analysis included randomized controlled trials (RCTs) that evaluated the effect of in-office bleaching with laser irradiation (Intervention) compared to bleaching with light activation other than a laser, or bleaching without irradiation (Comparison) on tooth sensitivity (Outcome) in patients undergoing tooth bleaching procedures (Population). This systematic review and meta-analysis included only controlled trials (RCTs) that evaluated the effect of laser irradiation during in-office bleaching procedures. The primary outcome of interest was tooth sensitivity, measured by the Visual Analog Scale (VAS) to assess the intensity of sensitivity or discomfort reported by participants. Studies were excluded if they met any of the following criteria: (1) They did not isolate the effect of laser irradiation (e.g., They employed hybrid light sources such as a laser combined with an LED, which confounds the individual effect of the laser); (2) They applied laser irradiation after the bleaching treatment rather than concurrently; or (3) they lacked access to full-text or failed to meet the other inclusion criteria.

Search databases and screening

Relevant literature published up to August 2025 was identified through a comprehensive search of PubMed, Web of Science, Scopus, and Google Scholar. The search strategy, formulated alongside an information specialist, incorporated keywords such as "laser," "bleaching," "tooth sensitivity," and "effectiveness" (Table 1). To ensure thoroughness and mitigate publication bias, manual reference checking and grey literature searches were additionally conducted. The initial search yielded 230 records. Following the removal of 88 duplicates, two independent reviewers (N.G., A.F.) screened the remaining 142 titles, excluding 71. Subsequent abstract screening removed 40 additional records. Disagreements were managed via consensus or third-party consultation. Finally, a full-text assessment of 31 articles resulted in the exclusion of 27 studies (unavailable full texts [n = 9], irrelevance [n = 3], or methodological disparities [n = 15]), culminating in 4 studies that met the criteria for meta-analysis. Across the included studies, diode lasers were applied with wavelengths ranging from 810 to 940 nm and power outputs of 3–10 W. All lasers were applied during the in-office bleaching procedure immediately after gel placement, using a full-arch irradiation protocol.[7,15-17] (Figure 1) & (Table 2)

Data extraction

Two independent reviewers utilized a standardized form to extract relevant data from the selected articles. The recorded information encompassed study characteristics (authors, publication year, design, and sample size), patient demographics (age, gender, and baseline sensitivity), details regarding the intervention and control groups, and primary outcomes—specifically tooth sensitivity as measured by the VAS. Data pertaining to quality assessment and risk of bias were also collected. Any disagreements during the extraction process were resolved through mutual consensus.

Quality assessment

The methodological quality of the included trials was evaluated using the Jadad scale to assess the risk of bias across various domains. Two independent reviewers categorized the risk of bias for each study as low, high, or some concerns. Any disagreements were resolved via discussion or by consulting a third reviewer.

Data synthesis

For data synthesis, a random-effects model was used to estimate the overall effect size (weighted mean difference, WMD) and its 95% confidence intervals (CIs). The primary effect size, standardized mean difference (SMD), were calculated to determine the magnitude of the difference in tooth sensitivity between the laser/light-assisted bleaching group and the bleaching-alone group. Statistical heterogeneity among the included studies was evaluated using the I^2 index, where thresholds of 25%, 50%, and 75% represented low, moderate, and high heterogeneity, respectively. Data analysis was conducted using Stata software, with statistical significance defined as $P<0.05$. To guarantee transparency and reproducibility, the findings were reported following the PRISMA guidelines.

Results

This systematic review and meta-analysis included four studies contributing a total of 14 effect sizes to evaluate

Table 1. Search strategy

Databases	Search Syntaxes
PubMed	("Tooth Bleaching"[Mesh] OR "Tooth Whitening" OR "Dental Bleaching" OR "In-office bleaching") AND ("Laser Therapy"[Mesh] OR laser OR "light activation" OR "photoactivation" OR "LED" OR "diode laser") AND ("Tooth Sensitivity"[Mesh] OR "dentin hypersensitivity" OR "tooth pain" OR "sensitivity") AND ("Randomized Controlled Trial"[Publication Type] OR "RCT" OR "randomized")
Scopus	(TITLE-ABS-KEY("tooth bleaching" OR "tooth whitening" OR "dental bleaching" OR "in-office bleaching")) AND (TITLE-ABS-KEY("laser" OR "light activation" OR "photoactivation" OR "LED" OR "diode laser")) AND (TITLE-ABS-KEY("tooth sensitivity" OR "dentin hypersensitivity" OR "tooth pain")) AND (TITLE-ABS-KEY("randomized controlled trial" OR "RCT" OR "randomised"))
Web of Sciences	TS=("tooth bleaching" OR "tooth whitening" OR "dental bleaching" OR "in-office bleaching") AND TS=("laser activation" OR "light activation" OR "photoactivation" OR "LED" OR "diode laser" OR "laser therapy") AND TS=("tooth sensitivity" OR "dentin hypersensitivity" OR "tooth pain" OR "sensitivity") AND TS=("randomized controlled trial" OR "randomised controlled trial" OR RCT)

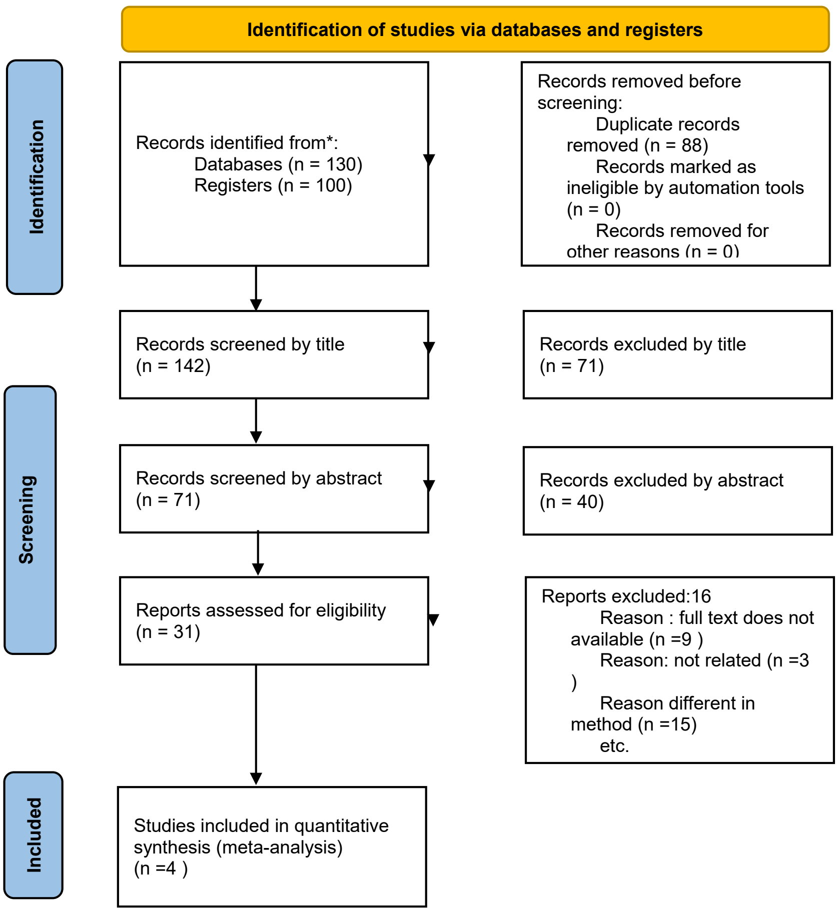

Figure 1. Flowchart showing the steps of the article selection process

Table 2. Summary of the characteristics of the included studies

Author	Year	Age	Sample size	Bleaching time	Light source time	Light source	Groups	DM	Mean ± SD	Median ± IQR/ baseline	Median ± IQR/ after
M. Sadri et al.[15]	2023	NR	30	2*15-20 min	2x30sec	diode laser, 940 nm, 10W,30s	35% HP + laser + Tooth Mousse	VAS	2.9 ± 1.72		
				2*15-20 min			35% HP + Tooth Mousse		2.33 ± 1.80		
				2*15-20 min	2x30sec	diode laser, 940 nm, 10W,30s	35% HP + Laser		3.93 ± 2.5		
				2*15-20 min			35% HP		2.66 ± 1.53		
Tekce et al.[7]	2022	23.7	70	14 min	2x30sec	diode laser, 940nm,7W	35% HP + Diode laser	VAS		0 ± 0-0	0 ± 0-0
				14min	2x8min	440-480nm, 1500mW/cm2	35% HP + LED			0 ± 0-0	2 ± 0-4
Ahrari et al.[16]	2020	14-30	60	14 days			20% carbamide peroxide gel	VAS	1		
				40 min	2x30sec	810 nm, 3 W for 30 s per tooth	46%HP + diode laser		0		
				40 min		400–490 nm, 2800 mW/cm2	35%HP + plasma arc device		0.4		
				40 min			40% HP		1.5		
Sevil Gurgan et al.[17]	2010	27.3	40	2*15 min			38% HP without light activation	VAS	3.37 ± 1.94		
				3*8min	8x15sec	Diode laser, 810 nm, 10W	37% HP with a diode laser		0.59 ± 0.92		
				3*20 min		PAC ,400–490 nm,2800 mV/ cm2	35% HP with a plasma arc lamp		3.80 ± 1.29		
				2*20 min		LED, 400–500 nm	38% HP with a LED		2.90 ± 1.48		

Abbreviations: HP, hydrogen peroxide; LED, light-emitting diode; NR, not reported; VAS, visual analogue scale

the impact of various interventions on post-bleaching tooth sensitivity (TH). In studies with a split-mouth or multi-arm design, multiple effect sizes per study were included to represent the different treatment groups or quadrants (e.g., Laser + Tooth Mousse, Tooth Mousse alone, Laser only, No intervention). Some studies reported outcomes as medians with interquartile ranges (IQR) or ranges instead of means and standard deviations (SDs). In these cases, standard statistical methods were applied to estimate means and SDs, enabling inclusion in the meta-analysis.

Across the included studies, diode lasers were applied with wavelengths ranging from 810 to 940 nm and power outputs of 3–10 W, immediately after bleaching gel placement, using a full-arch irradiation protocol.

Because paired pre- and post-intervention data were not consistently available, the analysis was conducted using post-intervention mean scores only. Accordingly, WMDs were calculated rather than Standardized Mean Differences (SMDs). A random-effects model with the REML method was used to account for variability across studies.

The pooled WMD showed a statistically significant reduction in post-bleaching tooth sensitivity (WMD = 1.174, 95% CI: 0.474 to 1.874, $P = 0.001$), indicating that, on average, the interventions led to a meaningful decrease in reported sensitivity (Figure 2).
However, there was substantial heterogeneity among studies ($I^2 = 99.93\%$, $\tau^2 = 0.8651$, Q = 1639.57, df = 13, $P < 0.001$), reflecting extreme inconsistency in effect sizes (Figure 3). Individual WMDs ranged from 0.000 (Tekce 2022; Ahrari 2020) to 3.930 (Sadri 2023) and 3.800 (Sevil Gurgan 2010), highlighting variability in intervention effectiveness. Studies such as Ahrari (2020) and Tekce (2022) reported minimal changes, while Sadri (2023) and Gurgan (2010) demonstrated substantial reductions in sensitivity. This variability likely arises from differences in study design, intervention protocols, measurement methods, and participant characteristics.

Jadad Score and risk of bias results

The methodological quality of the included randomized clinical trials was evaluated using the Jadad scale (Oxford quality scoring system). This instrument assesses randomization, blinding, and reporting of withdrawals or dropouts, with total scores ranging from 0 to 5 points. Studies scoring ≤ 2 were considered low quality, a score of 3 indicated moderate quality, and scores of 4–5 reflected high quality. A summary of the Jadad scoring for each included study is presented in Table 3. Among the four included studies, one study (Sevil Gurgan et al., 2010) achieved the highest quality score of 5, demonstrating appropriate randomization, double-blinding, and clear reporting of participant withdrawals. Two studies (Tekce et al., 2022; Ahrari et al., 2020) were rated as moderate quality (score = 3), as they reported randomization and withdrawals but lacked adequate blinding procedures due to visible differences between light activation techniques. One study (M. Sadri et al., 2023) was rated as low quality (score = 2), with randomization described but without details of the method or blinding (Table 3).

Discussion

Tooth sensitivity arises from the release of hydrogen

Table 3. Methodological Quality Assessment of Included Studies Using the Jadad Scale

Author (Year)	Randomized	Randomization Method Appropriate	Double-Blind	Blinding Method Appropriate	Withdrawals/Dropouts Reported	Jadad Score (0–5)	Quality Level
M. Sadri et al. (2023)[15]	Yes	No	No	No	Yes	2	Low
Tekce et al. (2022)[7]	Yes	Yes	No	No	Yes	3	Moderate
Ahrari et al. (2020)[16]	Yes	Yes	No	No	Yes	3	Moderate
Sevil Gurgan et al. (2010)[17]	Yes	Yes	Yes	Yes	Yes	5	High

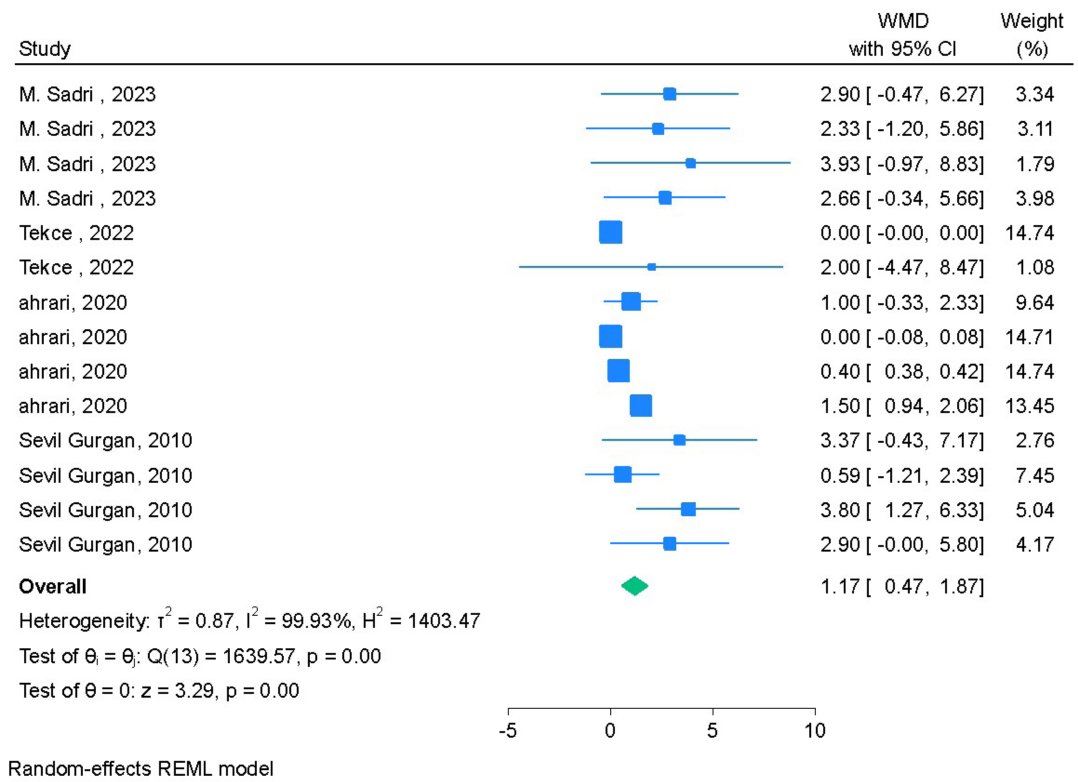

Figure 2. Forest Plot of Weighted Mean Differences in Sensitivity Reduction Across Intervention Groups (Laser+Tooth Mousse [LM], Tooth Mousse Alone [TM], Laser Only [L], and No Intervention [NI])

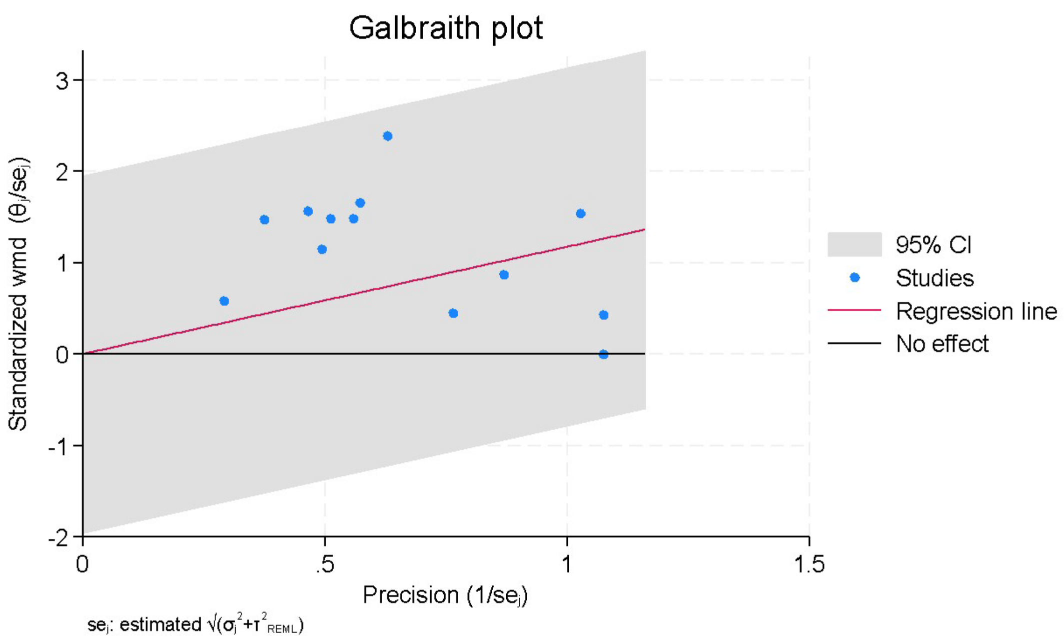

Figure 3. The Galbraith plot results related to heterogeneity

peroxide molecules, which penetrate the enamel and dentin to reach the pulp, causing pulp inflammation. This inflammation affects the sensory nerves, leading to increased sensitivity to external stimuli. Several factors, such as enamel cracks, dentin exposure, and the size of the pulp chamber, contribute to the severity of tooth sensitivity. In all studies, tooth sensitivity is evaluated using the Visual Analog Scale (VAS). [18] Sensitivity resulting from in-office bleaching is influenced by factors including the type and concentration of the bleaching agent, the duration of bleaching, and the light or heat source employed during the procedure. [19]

In this systematic review and meta-analysis, a significant difference in the reduction of tooth sensitivity was observed when lasers were used during in-office bleaching compared to when they were not. Thus, the research hypothesis was supported.

In modern tooth whitening treatments, practitioners utilize a diverse array of light and laser technologies. These range from standard halogen lamps, LEDs, and plasma arcs to non-thermal atmospheric pressure plasmas (NAPP) and specific laser systems, including argon, diode, and CO2. [20] Ahrari F et al. indicated that an LED (40-s irradiation with 380 mW/cm² light intensity) produces a low temperature. Also, plasma arc bleaching did not show any advantage over other in-office approaches in terms of color alteration and tooth sensitivity; therefore, this method could not be recommended as a preferred approach for whitening tooth color[16] . Liang S et al. suggested that although halogen-activated bleaching accelerates immediate aesthetic improvements, the chemical activation technique is deemed more conservative owing to its negligible thermal impact on the pulp chamber. [21] Harashima T et al. determined that, relative to other laser devices, the Er,Cr:YSGG system exhibits a higher level of interaction with water molecules and hydroxyapatite. [22] This attribute provides a protective advantage, as the thermal energy created at the outer enamel surface fails to penetrate the internal dental strata. [23]

The results of this study indicate that using lasers during bleaching treatment can help reduce tooth sensitivity compared to chemical and LED methods, aligning with previous studies. This finding can serve as a guide for clinicians to minimize sensitivity caused by bleaching. [24, 25] Ozge Parlar Oz et al. (2021) evaluated tooth sensitivity after in-office bleaching in four groups: bleaching material alone (40% H2O2), bleaching activated by an 810-nm diode laser, bleaching activated by an Nd:YAG laser, and bleaching activated by an LED for 6 months. Their results showed a statistically significant increase in sensitivity across all groups, with the highest sensitivity observed in the LED group. Their findings suggested that Nd:YAG and diode laser irradiation could be preferable alternatives to LED and chemical-only bleaching, causing minimal sensitivity. [24]

Derya Surmelioglu et al. assessed post-operative tooth sensitivity following in-office bleaching across three distinct groups over several months: chemical bleaching alone, diode laser-assisted bleaching, and Er,Cr:YSGG laser-assisted bleaching. Their findings indicated that while both chemical and diode-activated methods induced mild tooth sensitivity, the Er,Cr:YSGG laser group experienced no such adverse effects. This outcome can be attributed to the pulsed nature of the Er,Cr:YSGG laser, which delivers high power in brief bursts, facilitating rapid thermal dissipation. Consequently, it offers a distinct thermal advantage over continuous-wave lasers of comparable energy. Furthermore, the Er,Cr:YSGG wavelength possesses a significantly higher absorption rate in water and hydroxyapatite compared to alternative laser systems. This characteristic enhances procedural safety by confining heat generation to the superficial layers of the tooth, preventing thermal transmission to the internal dental structures. [25]

However, some studies have reported increased sensitivity following laser-activated bleaching, which differs from the present study. These discrepancies may be due to differences in hydrogen peroxide concentration, laser wavelength, and light source duration.

Aybuke Uslu Tekce et al. evaluated tooth sensitivity after in-office bleaching in two groups: bleaching activated by an LED (Radii Plus, SDI) and bleaching activated by a diode laser (Epic X, Biolase) for 9 months post-treatment. Their study found similar clinical performance between laser-activated and LED-activated bleaching in terms of tooth sensitivity.[7]

However, as observed in the results section of this study, the diode laser generates more heat compared to the LED, which enhances its whitening effect. Despite this, due to the anti-sensitivity properties of the laser, the level of tooth sensitivity was similar in both groups. Therefore, it can be concluded that the clinical performance of the diode laser was, in fact, superior to that of the LED.

Previous systematic reviews did not analyze the pure effect of laser irradiation during in-office bleaching on tooth sensitivity. Many included studies utilized hybrid light sources (combinations of laser and LED), making it difficult to isolate the specific impact of laser alone. [26] In contrast, our meta-analysis exclusively included studies that investigated the effect of laser independently, without the confounding influence of other light sources. This approach allows for a more accurate assessment of the isolated effect of laser on post-bleaching tooth sensitivity and represents a key strength of our study compared to prior reviews.

The limitations of this study include the small number of homogeneous studies, variations in sensitivity assessment time, intervention methods, and the use of additional desensitizers. Consequently, further clinical trials with standardized protocols are necessary to reduce potential biases.

In this study, only studies that specifically compared laser use during bleaching with other light sources were reviewed. This could be considered an advantage of this study over previous ones and a reason for the difference in results.

Conclusion

This systematic review and meta-analysis highlighted the effectiveness of laser-activated in-office bleaching in reducing tooth sensitivity compared to traditional chemical and LED methods. While lasers, particularly the diode laser, demonstrated a potential reduction in sensitivity, the clinical performance was comparable across different laser types and light activation methods. The findings suggest that laser-activated bleaching treatments may offer an effective solution for minimizing sensitivity during whitening procedures, providing an advantage over conventional bleaching techniques.

Despite some inconsistencies between studies, which could be attributed to variations in bleaching protocols, light sources, and sensitivity assessment methods, the results support the use of laser therapy as a beneficial adjunct in whitening treatments. Further clinical trials with standardized protocols are essential to refine the application of lasers and establish more definitive guidelines.

Ultimately, laser-activated bleaching treatments may serve as an optimal choice for patients seeking effective, minimally sensitive whitening solutions, and this study provides valuable insights for clinicians aiming to enhance patient comfort during in-office bleaching procedures.

Authors' Contribution

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Competing Interests

The authors declare that they have no conflict of interests.

Ethical Approval

None.

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References

1. Amirifar S, Ahmadi E, Najafrad E, Rafeie N. Combined minimally invasive treatment of teeth discoloration caused by occupational exposure to bronze alloy. Int J Dent 2022;2022:3399120. doi:10.1155/2022/3399120
2. Alqahtani MQ. Tooth-bleaching procedures and their controversial effects: a literature review. Saudi Dent J 2014;26(2):33-46. doi:10.1016/j.sdentj.2014.02.002
3. Ahrari F, Akbari M, Mohammadpour S, Forghani M. The efficacy of laser-assisted in-office bleaching and home bleaching on sound and demineralized enamel. Laser Ther 2015;24(4):257-64. doi:10.5978/islsm.15-OR-15
4. Mondelli RF, Gabriel T, Rizzante FA, Magalhães AC, Bombonatti JF, Ishikiriama SK. Do different bleaching protocols affect the enamel microhardness? Eur J Dent 2015;9(1):25-30. doi:10.4103/1305-7456.149634
5. Irusa K, Abd Alrahaem I, Ngoc CN, Donovan T. Tooth whitening procedures: a narrative review. Dent Rev 2022;2(3):100055. doi:10.1016/j.dentre.2022.100055
6. He LB, Shao MY, Tan K, Xu X, Li JY. The effects of light on bleaching and tooth sensitivity during in-office vital bleaching: a systematic review and meta-analysis. J Dent 2012;40(8):644-53. doi:10.1016/j.jdent.2012.04.010
7. Tekce AU, Yazici AR. Clinical comparison of diode laser- and LED-activated tooth bleaching: 9-month follow-up. Lasers Med Sci 2022;37(8):3237-47. doi:10.1007/s10103-022-03612-1
8. Alshammery S. Evaluation of light activation on in-office dental bleaching: a systematic review. J Contemp Dent Pract 2019;20(11):1355-60.
9. Luk K, Tam L, Hubert M. Effect of light energy on peroxide tooth bleaching. J Am Dent Assoc 2004;135(2):194-201. doi:10.14219/jada.archive.2004.0151
10. Vochikovski L, Favoreto MW, Rezende M, Terra RM, Gumy FN, Loguercio AD, et al. Use of infrared photobiomodulation with low-level laser therapy for reduction of bleaching-induced tooth sensitivity after in-office bleaching: a double-blind, randomized controlled trial. Lasers Med Sci 2022;38(1):18. doi:10.1007/s10103-022-03682-1
11. Naghsh N, Kachuie M, Bijari M, Birang R. Evaluation of the effects of 980 and 810-nm high-level diode lasers in treating dentin hypersensitivity: a double-blinded randomized clinical trial. Dent Res J (Isfahan) 2022;19:96.
12. Femiano F, Femiano R, Femiano L, Aresu G, Festa VM, Rullo R, et al. Effectiveness of low-level diode laser therapy on pain during cavity preparation on permanent teeth. Am J Dent 2018;31(5):267-71.
13. Kantola S. Laser-induced effects on tooth structure. VII. X-ray diffraction study of dentine exposed to a CO2 laser. Acta Odontol Scand 1973;31(6):381-6. doi:10.3109/00016357309002525
14. Ehlers V, Ernst CP, Reich M, Kämmerer P, Willershausen B. Clinical comparison of gluma and Er:YAG laser treatment of cervically exposed hypersensitive dentin. Am J Dent 2012;25(3):131-5.
15. Sadri M, Nakhostin A, Salamat F. Effects of laser irradiation and tooth mousse on tooth hypersensitivity after office bleaching: a non-randomized clinical trial. Dent Res J (Isfahan) 2023;20:24. doi:10.4103/1735-3327.369626
16. Ahrari F, Akbari M, Mohammadipour HS, Fallahrastegar A, Sekandari S. The efficacy and complications of several bleaching techniques in patients after fixed orthodontic therapy. A randomized clinical trial. Swiss Dent J 2020;130(6):493-501. doi:10.61872/sdj-2020-06-02
17. Gurgan S, Cakir FY, Yazici E. Different light-activated in-office bleaching systems: a clinical evaluation. Lasers Med Sci 2010;25(6):817-22. doi:10.1007/s10103-009-0688-x
18. Rocha MO, Cruz A, Santos DO, Douglas-de-Oliveira DW, Flecha OD, Gonçalves PF. Sensitivity and specificity of assessment scales of dentin hypersensitivity - an accuracy study. Braz Oral Res 2020;34:e043. doi:10.1590/1807-3107bor-2020.vol34.0043
19. Joiner A. The bleaching of teeth: a review of the literature. J Dent 2006;34(7):412-9. doi:10.1016/j.jdent.2006.02.002
20. Mondelli RF, Soares AF, Pangrazio EG, Wang L, Ishikiriama SK, Bombonatti JF. Evaluation of temperature increase during in-office bleaching. J Appl Oral Sci 2016;24(2):136-41. doi:10.1590/1678-775720150154
21. Liang S, Sa Y, Jiang T, Ma X, Xing W, Wang Z, et al. In vitro evaluation of halogen light-activated vs chemically activated in-office bleaching systems. Acta Odontol Scand

2013;71(5):1149-55. doi:10.3109/00016357.2012.757355

22. Harashima T, Kinoshita J, Kimura Y, Brugnera A, Zanin F, Pecora JD, et al. Morphological comparative study on ablation of dental hard tissues at cavity preparation by Er:YAG and Er,Cr:YSGG lasers. Photomed Laser Surg 2005;23(1):52-5. doi:10.1089/pho.2005.23.52
23. Buchalla W, Attin T. External bleaching therapy with activation by heat, light or laser--a systematic review. Dent Mater 2007;23(5):586-96. doi:10.1016/j.dental.2006.03.018
24. Parlar Oz O, Demirkol N. Effectiveness of in-office bleaching treatment with different activation techniques on tooth color changes and sensitivity: a randomized clinical trial. Am J Dent 2021;34(1):23-30.
25. Sürmelioğlu D, Torun ÖY. Evaluation of effectiveness and postoperative sensitivity following ozone and laser activated bleaching methods. J Dent Fac Ataturk Univ 2019;29(3):416-23. doi:10.17567/ataunidfd.566815
26. Casado B, Pellizzer EP, Souto Maior JR, Lemos C, Vasconcelos B, Moraes S. Laser influence on dental sensitivity compared to other light sources used during in-office dental bleaching: systematic review and meta-analysis. Oper Dent 2020;45(6):589-97. doi:10.2341/19-064-l