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Effectiveness of Light Sources on In-Office Dental Bleaching: A Systematic Review and Meta-Analyses

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Clinical Relevance

The use of in-office bleaching techniques with light sources is recommended to improve the performance of bleaching gels. The use of hydrogen peroxide alone, without light, is effective for achieving tooth color changes.

SUMMARY

Objective: A systematic review and meta-analyses were performed to evaluate the efficacy of tooth color change and sensitivity of teeth following in-office bleaching with and without light gel activation in adult patients.

Methods: This review was registered at PROSPERO (CRD 42017060574) and is based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Electronic systematic searches of PubMed/MEDLINE, Web of Science, and the Cochrane Library were conducted for published articles. Only randomized clinical trials among adults that compared in-office bleaching with and without light activation with the same bleaching gel concentrations were selected. The outcomes were tooth color change and tooth sensitivity prevalence and intensity.

Results: Twenty-three articles from 1054 data sources met the eligibility criteria. After title and abstract screening, 39 studies remained. Sixteen studies were further excluded. Twenty-three studies remained for qualitative

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analyses and 20 for meta-analyses of primary and secondary outcomes. No significant differences in tooth color change or tooth sensitivity incidence were found between the compared groups; however, tooth sensitivity intensity decreased when light sources were applied.

Conclusion: The use of light sources for in-office bleaching is not imperative to achieve esthetic clinical results.

INTRODUCTION

The effectiveness, minimally invasive procedure, and biological safety are some of the reasons for the frequent request for tooth bleaching treatment by patients with discolored teeth.[1] Although tooth bleaching is generally considered to be a safe and simple treatment, some studies suggest that in-office dental bleaching could result in side effects to dental and gingival tissues, mainly when higher concentrations of hydrogen peroxide are used.[2] Tooth sensitivity during and after treatment is the major side effect observed.[3]

The chemical reaction rates between bleaching gels and dental pigments are proportional to the effectiveness of the bleaching agent.[4] Methods that increase chemical reaction rates improve treatment efficiency and comfort. For example, bleaching with light sources is recommended for in-office bleaching treatments, to accelerate the action of bleaching gels.[5]

There are many types of light sources for bleaching activation, such as lasers, light-emitting diodes (LEDs), and plasma arc (PAC) and halogen lamps.[6] The purpose of using light units is to heat the hydrogen peroxide,[7] which increases the rate of oxygen decomposition to form oxygen free radicals, thereby enhancing the release of stain containing molecules.[8]

Despite many light activation systems being introduced into the dental market for accelerating in-office bleaching treatments,[5] it is important to analyze tooth surface color changes and sensitivity when performing in-office bleaching with light sources. Therefore, the aim of this systematic review with meta-analyses was to evaluate the effects of light activation on bleaching effectiveness and tooth sensitivity during in-office bleaching. The null hypothesis was that light does not influence tooth color change. The second hypothesis was that light influences tooth sensitivity.

METHODS AND MATERIALS

Registration Protocol

This systematic review is based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist described by Moher and others.[9] The study was registered on the International Prospective Register of Systematic Reviews (PROSPERO; CRD 42017060574).

Eligibility Criteria

Studies were selected and included/excluded, based on the article title and abstract, by two researchers (J.R.S.M and C.A.A.L), working independently. Eligible studies included randomized controlled trials (RCTs) and studies that compared in-office light- vs non-light-activated bleaching systems, using the same bleaching gel concentration, with at least 10 participants, published in English. Exclusion criteria were prospective nonrandomized and retrospective studies, in vitro studies, animal studies, computer simulations, case reports, studies that evaluated associations with techniques, and published report reviews.

A specific question was formulated based on population, intervention, control, and outcome (PICO) criteria. The question was "Can light-activation of in-office whitening systems influence bleaching effectiveness and tooth sensitivity?" According to these criteria, the population was the participants who had their teeth bleached with an in-office whitening system, the intervention was in-office light-activated tooth bleaching, and the comparison was in-office non-light-activated tooth bleaching. The primary outcome was the effectiveness of dental bleaching, and the secondary outcome was tooth sensitivity.

Search Strategy and Information Sources

Two independent investigators (J.R.S.M and C.A.A.L) conducted an electronic search of PubMed/MEDLINE, Web of Science, and the Cochrane Library for articles published between January 2000 and May 2017, using the following search terms: "tooth bleaching and light"; "dental bleaching and light."

The same researchers manually searched for articles published in *Operative Dentistry, Journal of Dentistry, Journal of Dental Research, Journal of Esthetic and Restorative Dentistry,* and *Quintessence International*. All choice differences between the investigators were analyzed by a third investigator

(S.L.D.M), and consensus was reached through discussion.

Data Analysis

Data extracted from the articles were classified as quantitative or qualitative by one of the researchers and then checked by another. Any disagreements were resolved via discussion until consensus was reached.

Risk of Bias

Two investigators (J.R.S.M. and C.A.A.L) assessed the methodologic quality of the included studies, as well as the risk of bias based on the Cochrane collaboration criteria.[10]

Summary Measures

The meta-analysis was based on the Mantel-Haenzel (MH) and inverse variance (IV) methods. Data from eligible studies were either dichotomous (absolute risk of tooth sensitivity) or continuous (intensity of tooth sensitivity, subjective and objective color variation). Bleaching technique was considered a continuous outcome, evaluated by mean differences (MDs) and corresponding 95% confidence intervals (CIs). Tooth sensitivity was considered a dichotomous outcome, evaluated by risk ratio (RR). RR and MD values were considered significant when $p<0.05$. The software Reviewer Manager 5 (Cochrane Group) was used for the meta-analyses. Heterogeneity analyses evaluated the I^2 value (25% low, 50% moderate, and 75% high). The meta-analyses effects were based on the heterogeneity study. Where heterogeneity was statistically significant ($p<0.10$), random effects meta-analyses were conducted; otherwise, meta-analyses were performed from fixed effects.[11]

Additional Analysis

The κ score was used to calculate agreement between the researchers during the selection process. Any disagreements were resolved by discussion and the consensus of all authors.

RESULTS

Literature Search

The database search retrieved 1054 references, including 670 from PubMed/MEDLINE, 276 from Web of Science, and 108 from The Cochrane Library. After duplicate references were removed, a detailed review was carried out of the titles and abstracts of the selected comparative studies, and after applying the inclusion/ exclusion criteria, 39 full papers were selected for eligibility assessment (Figure 1). After reading the full texts of these articles, 23 studies were included in the final review.[5,6,12-25] Reasons for study exclusion are detailed in Figure 1.

Characteristics of the Included Studies

Detailed data of the 23 included studies are listed in Table 1. All selected studies were RCTs. Among these studies, 15 compared bleaching efficacy.[6,12,14,16,18,19,22-30] and 13 compared tooth sensitivity.[4,5,6,14,16,17,19-21,23-25,27]

A total of 925 patients were included in the 23 studies, and the sample size of each study ranged from 20 to 88 patients. In nine articles, most participants were females, whereas 14 studies did not report this information. Hydrogen peroxide (HP) was used as the agent for in-office bleaching in all studies. The HP percentages were 35% in 15 studies,[4,5,12,13,16-21,23,24,26,28,30] 38%[6,18,29] and 25%[14,15,22] in three studies, 20% in two studies,[24,25] and 15% in two studies.[27,31]

Thirteen studies used a shade guide for color evaluation.[6,12,16,19,22-30] Six of these added an objective instrument (spectrophotometer or colorimeter) for color assessment.[12,14,18,24,29,30] Three studies did not evaluate color. For pain evaluation, eight of the 13 studies used a 0-10 visual analog scale.[4,6,14,17,19-21,25]

Assessment of Methodologic Quality

Few of the selected studies provided details on all items of the Cochrane risk of bias tool. To request further information, e-mails were sent to 14 authors. Two authors replied with the requested information. Each trial was assessed for risk of bias; the scores are summarized in Figure 2.

In summary, the scores showed a higher number of studies remaining unclear for the random sequence generation and allocation concealment items. Apart from participant blinding, personnel and outcome assessment, incomplete outcome, and selective reporting items, a low risk of bias was observed.

Meta-Analysis

Bleaching Efficacy—Bleaching efficacy was observed by subjective (Vita Classical shade guide) and objective (spectrophotometer) tooth color change methods. For better comprehension, the color evaluations were divided into subgroups: immediate

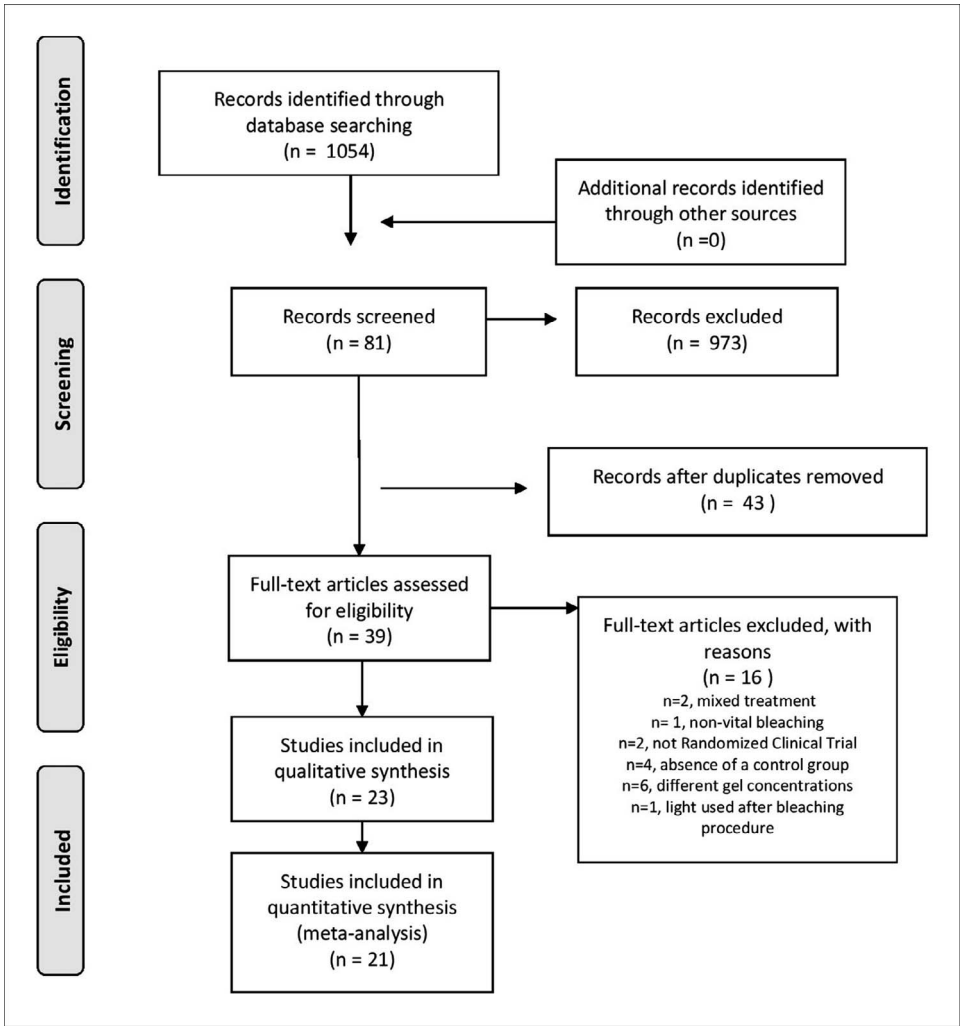

Figure 1. *Flowchart of the literature search.*

(within one day), short-term (one to four weeks), and medium-term (greater than four weeks) effects, depending on the time of evaluation.

Immediate Effect—Eight studies assessed immediate bleaching efficacy using visual measurements.[14,16,19,25-30] Random effects showed no significant differences between light and non-light bleaching (p=0.38; MD: −0.38; CI: −1.24 to 0.47). The data was heterogeneous (χ^2:178.87; I^2 = 94%; p<0.00001; Figure 3), and all studies included in the analysis did not share a common effect size. After a detailed analysis of the studies and even after excluding the study with the highest difference between the experimental and control groups,[29] the results remained the same, and the heterogeneity was unchanged. Lack of relevant studies prevented us from performing meta-regression or subgroup analysis.

Short-Term Effect (One to Four Weeks)—As shown in Figure 4, eight studies reported short-term bleaching efficacy assessed by visual measurements. In all studies, random effects showed no significant difference between light and non-light bleaching techniques (p=0.63; MD: 0.16; CI: −0.5 to 0.83) The data were heterogeneous (χ^2: 31.02; I^2 = 65%; p=0.001; Figure 4), and all studies included in the analysis did not share a common effect size. After a detailed analysis, it was not possible to identify any studies that were responsible for the high heterogeneity.

Medium-Term Effect (More Than 4 Weeks)—Four studies reported medium-term bleaching efficacy assessed by visual measurements. The results showed no difference between light and non-light bleaching techniques (p=0.60; MD: −0.23; CI: −1.07 to 0.62). The data were heterogeneous (χ^2: 24.76; I^2 = 84%; p<0.00001; Figure 5), and all studies included in the analysis did not share a common effect size. After a detailed analysis, it was not possible to

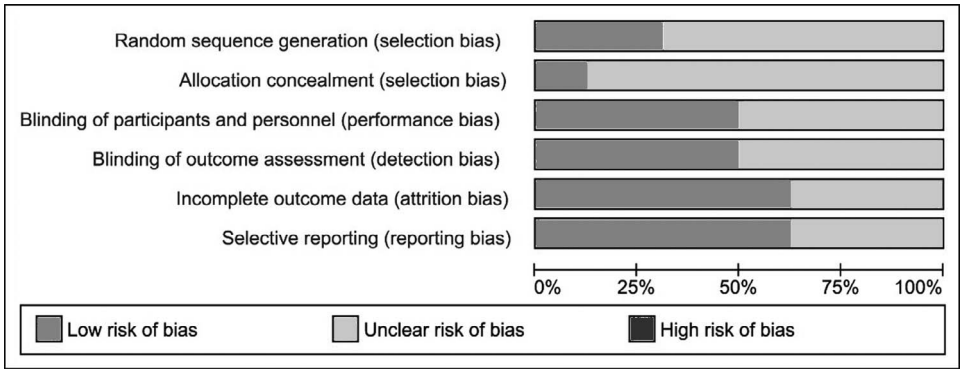

Figure 2. *Risk of bias graph.*

identify any studies that were responsible for the high heterogeneity.

Tooth Sensitivity—Tooth sensitivity was divided into two categories: incidence and intensity. The intensity was determined when the patient quantified his pain response on a visual analogue scale, while the incidence was evaluated by the number of sensitivity events.

Intensity of Tooth Sensitivity—To evaluate tooth sensitivity, six studies [4,6,14,17,19,20] were assessed by continuous outcome data via visual analogue scales. Random effects showed a significant difference in favor of light bleaching systems (p=0.01; MD: −2.19; CI: −3.85 to −0.53) Light systems demonstrated a significantly lower intensity of tooth sensitivity than non-light systems (Figure 6). However, data were heterogeneous (χ^2: 325.81; $I^2 = 98\%$; $p<0.0001$), and all studies included in the analysis did not share a common effect size. After a detailed analysis, the study of Bortolato and others[4] did have an impact on the high heterogeneity of this outcome. When this study was removed from the present meta-analysis, the heterogeneity was not significant, and the overall mean difference was shown as significant

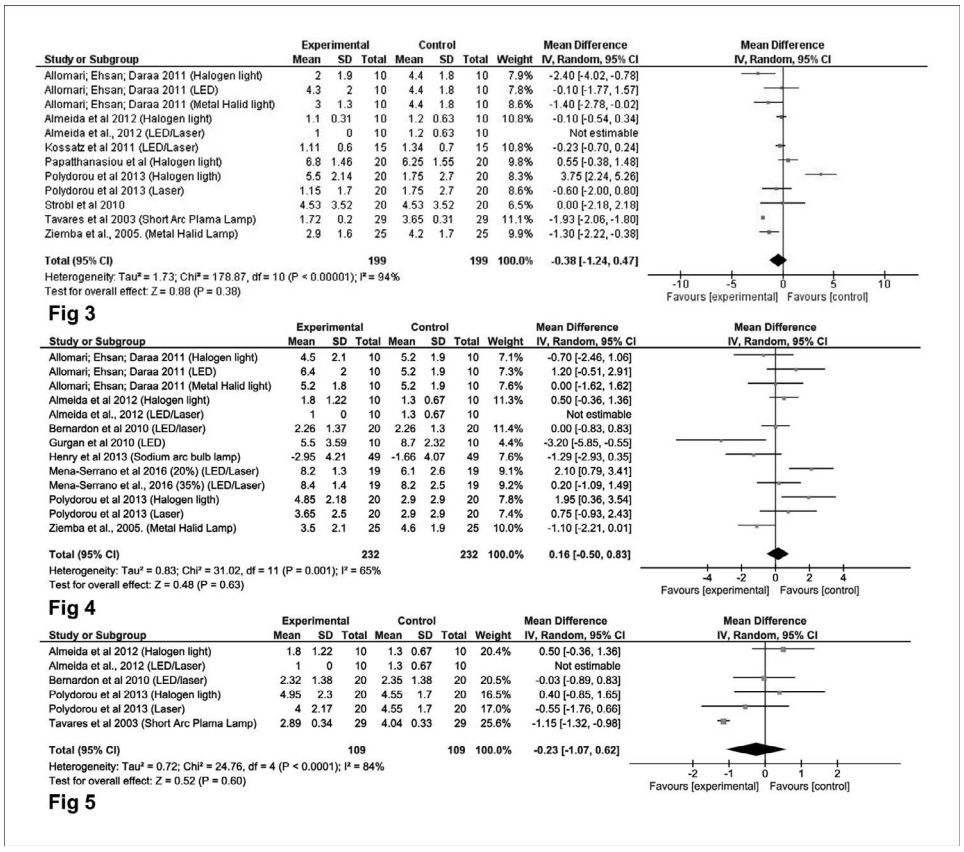

Figure 3. *Forest plot for the event "immediate color change."*

Figure 4. *Forest plot for the event "short-term effect color change."*

Figure 5. *Forest plot for the event "medium-term effect color change."*

Table 1: *Characteristics of the analyzed studies*

Author/Date	Study	Sample Size	Sex	Light Source (N)	Bleaching Agent
Papathanasiou and others, 2002[26]	RCT	20	NR	Without light (20)	35% HP
				Halogen light (20)	
Tavares and others, 2003[27]	RCT	87	M: 38 (43.67%) F: 49 (56.33%)	Without light (29)	15% HP
				Short arc plama lamp (29)	
Goodson and others, 2005[31]	RCT	NR	NR	Without light (NR)	15% HP
				Short arc plasma lamp (NR)	
Ziemba and others, 2005[25]	RCT	50	NR	Without light (25)	20% HP
				Metal halide lamp (25)	
Marson and others, 2008[5]	RCT	40	NR	Without light (10)	35% HP
				Halogen light (10)	
				LED (10)	
				LED/laser (10)	
Ontiveros and others, 2009[14]	RCT	20	NR	Without light (20)	25% HP
				Short-arc halide lamp(20)	
Kugel and others, 2009[15]	RCT	22	NR	Without light (11)	25% HP
				LED (11)	
Allomari and others, 2010[19]	RCT	40	M: 12 (30%) F: 28 (70%)	Without light (10)	35% HP
				Halogen light (10)	
				LED (10)	
				Metal halide light (10)	
Calatayud and others, 2010[13]	RCT	21	NR	Without light (21)	35% HP
				LED (21)	
Bernardon and others, 2010[12]	RCT	20	NR	Without light (20)	35% HP
				LED/laser (20)	
Strobl and others, 2010[30]	RCT	20	M:7 (35%) F:13 (65%)	Without light (20)	35% HP
				Laser (20)	
Gurgan and others, 2010[6]	RCT	40	M: 11 (27.5%) F: 29(72,5%)	Without light (10)	38% HP
				LED (10)	
Kossatz and others, 2011[16]	RCT	30	NR	Without light (15)	35% HP
				LED/Laser (15)	
Almeida and others, 2012[17]	RCT	30	NR	Without light (10)	35% HP
				Halogen light (10)	
				LED/laser (10)	

Table 1: *Characteristics of the analyzed studies (ext.)*

Author/Date	Bleaching Time	Subjective Shade Evaluation	Objective Shade Evaluation	Tooth Sensitivity
Papathanasiou and others, 2002[26]	20′ × 1	IM: 6.25 ± 1.55	NR	NR
	20′ × 1	IM: 6.8 ± 1.46	NR	NR
Tavares and others, 2003[27]	20′ × 3	IM: 3.65 ± 0.31	NR	IM: 29 (29)
		MT: 4.04 ± 0.33		ST: 23 (39)
	20′ × 3	IM: 1.72 ± 020	NR	IM: 29 (29)
		MT: 2.89 ± 0.34		ST: 25 (29)
Goodson and others, 2005[31]	20′ × 3	NR	NR	NR
	20′ × 3			
Ziemba and others, 2005[25]	15′ × 3	IM: 4.2 ± 1.7	NR	IM:0.4 ± 0.9
		ST:4.6 ± 1.9		ST: 0.2 ± 0.4
	15′ × 3	IM:2.9 ± 1.6	NR	IM:0.7 ± 1.4
		ST: 3.5 ± 2.1		ST: 0.2 ± 0.4
Marson and others, 2008[5]	15′ × 3	NR	NR	ST: 6 (10)
	15′ × 3	NR	NR	ST: 5 (10)
	15′ × 3	NR	NR	ST: 8 (10)
	15′ × 3	NR	NR	ST: 6 (10)
Ontiveros and others, 2009[14]	15′ × 3	6.1 ± 3.1	ST: 2.8 ± 1.5	IM:1.4 ± 1.6
	15′ × 3	4.7 ± 2.2	ST: 3.8 ± 1.4	IM: 2.8 ± 3.0:
Kugel and others, 2009[15]	20′ × 3	NR	NR	IM:6 (10)
	20′ × 3 +20′ light	NR	NR	IM:10 (11)
Allomari and others, 2010[19]	20′ × 3	IM: 4.4 ± 1.8	NR	IM: 0.3 ± 0.5
		ST: 5.2 ± 1.9		
	20′ × 3	IM: 2.0 ± 1.9	NR	IM: 0.8 ± 0.4
		ST: 4.5 ± 2.1		
	20′ × 3	IM: 4.3 ± 2.0	NR	IM: 1.00 ± 0.0
		ST: 6.4 ± 2.0		
	20′ × 3	IM: 3.0 ± 1.3	NR	IM: 0.8 ± 0.4
		ST: 5.2 ± 1.8		
Calatayud and others, 2010[13]	10′ × 2	NR	NR	NR
	10′ × 2	NR	NR	NR
Bernardon and others, 2010[12]	15′ × 3	ST:2.26 ± 1.30	ST: 8.41 ± 3.14	NR
		MT:2.59 ± 1.45	MT: 8.03 ± 3.08	
	15′ × 3	ST:2.26 ± 1.37	ST: 8.76 ± 3.40	NR
		MT: 2.45 ± 1.34	MT: 8.37 ± 3.08	
Strobl and others, 2010[30]	1′45′′ × 3	IM: 4.53 ± 3.52	IM:5.83 ± 3.17	NR
	1′45′′ × 3	IM: 4.53 ± 3.52	IM:5.39 ± 3.0	NR
Gurgan and others, 2010[6]	15′ × 2	ST: 8.7 ± 2.32	5.54 ± 0.15	IM: 3.37 ± 1.94
	20′ × 2	ST: 8.5 ± 3.59	5.43 ± 0.20	IM: 2.9 ± 1.48
Kossatz and others, 2011[16]	15′ × 3	IM: 1.34 ± 0.7	NR	IM:13 (15)
	15′ × 3, 1′ light + 2′ without light 3 times	IM: 1.11 ± 0.6	NR	IM:15(15)
Almeida and others, 2012[17]	10′ × 3	NR	NR	IM: 2.8 ± 3.01
	10′ × 3, 3 × 20” light	NR	NR	IM: 2.8 ± 2.97
	10′ × 3 + 3 × 3′ light	NR	NR	IM: 2.2 ± 3.22

Table 1: *Characteristics of the analyzed studies (cont.)*

Author/Date	Study	Sample Size	Sex	Light Source (N)	BleachingAgent
Mondelli and others, 2012[18]	RCT	32	NR	Without light (16)	35% HP
				LED/laser (16)	
				Without light (16)	38% HP
				LED/laser (16)	
Almeida and others, 2012[28]	RCT	30	NR	Without light (10)	35% HP
				Halogen light (10)	
				LED/laser (10)	
Polydorou and others, 2013[29]	RCT	60	NR	Without light (20)	38% HP
				Halogen light (20)	
				Laser (20)	
Moncada and others, 2013[20]	RCT	87	M: 13 (27%) F: 64 (73%)	Without light (35)	35% HP
				LED/laser (27)	
Martin and others, 2013[21]	RCT	88	M: 23 (18,4%) F: 65 (81.6%)	Without light (NR)	35% HP
				LED/laser (NR)	
Henry and others, 2013[22]	RCT	49	M: 24 (48.9%) F: 25 (51.02%)	Without light (49)	25% HP
				Sodium arc bulb lamp (49)	
Bortolato and others, 2013[4]	RCT	40	NR	Without light (20)	35% HP
				LED/laser (20)	
Freitas and others, 2016[23]	RCT	22	M: 10 (45.4%) F: 12 (54.6%)	Without light (22)	35%HP
				LED/laser (22)	
Mena-Serrano and others, 2016[24]	RCT	77	M: 27 (35%)	Without light (19)	20%HP
				LED/laser (19)	
			F: 50 (65%)	Without light (19)	35% HP
				LED/laser (19)	

F, female; IM, immediate effect; M, male; MT, medium-term effect; NR, not related; ST, short-term effect.

Table 1: *Characteristics of the analyzed studies (ext.) (cont.)*

Author/Date	Bleaching Time	Subjective Shade Evaluation	Objective Shade Evaluation	Tooth Sensitivity
Mondelli and others, 2012[18]	15′ × 3	NR	IM: 7.8 ± 1.42	NR
			ST: 5.64 ± 1.45	
			MT: 4.49 ± 1.45	
	11 × 3 + 3 × 3′ light	NR	IM: 7.49 ± 1.45	NR
			ST:5.43 ± 1.47	
			MT: 4.33 ± 1.39	
	15′ × 3	NR	IM: 7.83 ± 1.39	NR
			ST: 5.78 ± 1.37	
			MT: 4.64 ± 1.26	
	11′ × 3 + 3 × 3′ light	NR	IM: 7.76 ± 1.5	NR
			ST: 5.64 ± 1.38	
			MT: 4.42 ± 1.47	
Almeida and others, 2012[28]	10′ × 3	IM: 1.2 ± 0.63	NR	NR
		ST: 1.3 ± 0.67		
		MT: 1.3 ± 0.67		
	10′ × 3, 3 × 20′′ light	IM: 1.1 ± 0.31	NR	NR
		ST: 1.8 ± 1.22		
		MT: 1.8 ± 1.22		
	10′ × 3, 3 × 3′ light	IM: 1.0 ± 0.00	NR	NR
		ST: 1.0 ± 0.0		
		MT: 1.0 ± 0.00		
Polydorou and others, 2013[29]	15′ × 4	IM: 1.75 ± 2.7	IM: 4.8 ± 3.7	NR
		ST: 2.9 ± 2.9	ST: 7.25 ± 2.9	
		MT: 4.55 ± 1.7	MT: 7.05 ± 2.3	
	15′ × 4 + 8′ light	IM: 5.5 ± 2.94	IM: 6.1 ± 1.9	NR
		ST: 4.85 ± 2.18	ST: 5.55 ± 2.2	
		MT: 4.95 ± 2.3	MT: 5.1 ± 2.1	
	15′ × 4 + 30” light	IM: 1.15 ± 1.7	IM: 2.15 ± 2.4	NR
		ST: 3.65 ± 2.5	ST: 6.75 ± 3.2	
		MT: 4 ± 2.17	MT: 6.7 ± 2.8	
Moncada and others, 2013[20]	45′	NR	NR	IM: 31.51 ± 29.34
				ST: 7.23 ± 9.2
	10′ × 3 + 6′ light × 3	NR	NR	IM: 42.40 ± 31.78
				ST: 8.68 ± 17.99
Martin and others, 2013[21]	45′	NR	NR	IM: 31.51 ± 29.34
				ST: 9.65 ± 12.78
	10′ × 3 + 5× light cycles, 1′30 “ each	NR	NR	IM: 42.41 ± 31.78
				ST: 10.24 ± 18.56
Henry and others, 2013[22]	15′ × 3	ST: −1.66 ± 4.07	NR	NR
	15′ × 3	ST: −2.95 ± 4.21	NR	NR
Bortolato and others, 2013[4]	15′ × 3	NR	NR	IM: 37.6 ± 5.9
	8′ × 3 + 4× light cycles, 1′ each hemiarc	NR	NR	IM: 11.1 ± 3.3
Freitas and others, 2016[23]	15′ × 3	ST: 3.3	NR	IM: 10 (22)
	8′ × 3 + 3× light cycles, 1′ each hemiarc	ST: 3.8	NR	IM: 8 (22)
Mena-Serrano and others, 2016[24]	15′ × 3	ST: 6.1 ± 2.6	ST: 13.2 ± 4.1	IM: 12 (19)
	15′ × 3 + 1′ light+ 2′ without light × 3	ST: 8.2 ± 1.3	ST: 11.8 ± 4.0	IM: 14 (19)
	15′ × 3	ST: 8.2 ± 2.5	ST: 12.4 ± 3.7	IM: 15 (19)
	15′ × 3 + 1′ light+ 2′ without light × 3	ST: 8.4 ± 1.4	ST: 14.1 ± 2.9	IM: 16 (19)

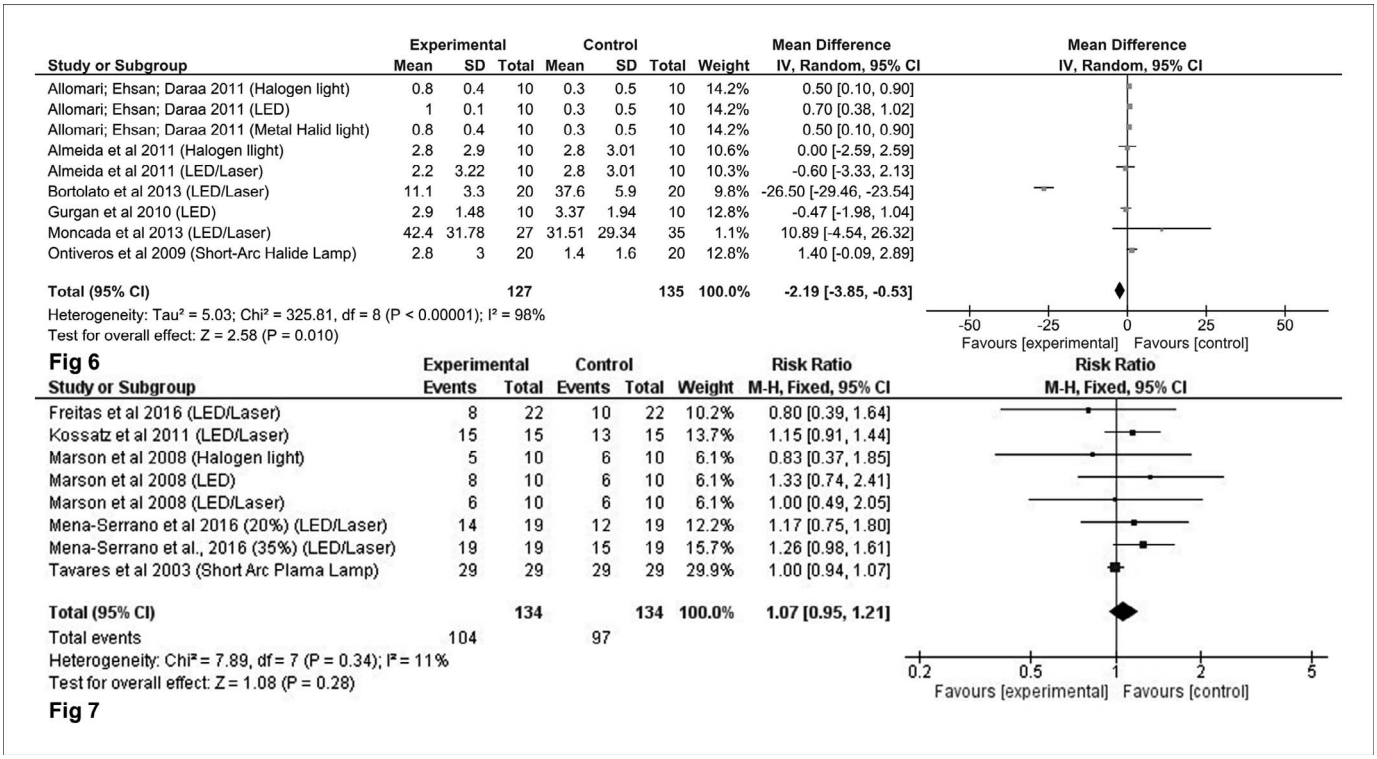

Figure 6. *Forest plot for the event "immediate sensitivity intensity."*
Figure 7. *Forest plot for the event "immediate sensitivity incidence."*

with a lower chance of tooth sensitivity for the non-light bleaching procedure (data not shown).

Incidence of Tooth Sensitivity—The incidence of tooth sensitivity between light and non-light bleaching systems according to visual analogue scale scores was assessed in four studies.[5,16,23,27] RRs showed that there were no differences between light- and non-light-activated bleaching systems (p=0.28; MD: 1.07; CI: 0.95 to 1.21). Heterogeneity was not significant (χ^2: 7.89; I^2 = 11%; p=0.33; Figure 7), and all studies included in the analysis did share a common effect size, suggesting that there are no differences in the incidences of tooth sensitivity between the two bleaching protocols (Figure 7).

DISCUSSION

In the present study, no significant differences were observed in bleaching efficacy, as measured by color change, between light- and non-light-activated bleaching systems, independent of time (immediate, short term, or medium term). Thus, we can accept the first null hypothesis. These results were corroborated with other published studies.[12,14,23,28] However, there have been other studies that observed better results when light was used with hydrogen peroxide.[14,15,25,27]

The use of hydrogen peroxide alone, without light, is effective for improving tooth color changes.[13] These results could be justified because high-concentration (25%-35%)[32] hydrogen peroxide already contains sufficient amounts of radicals to produce bleaching by chemical degradation only, without the use of light.[32] The light source could improve the tooth color change, when applied to low-concentration (15%-20%)[32] in-office hydrogen peroxide gel.[24] This is probably because the light improves the quantity of hydroxyl radicals available to compensate for the gel concentration.[16]

In some studies, the light had no influence on tooth color change,[12,16,18] whereas in others, light accelerated tooth bleaching in short-term evaluation.[15,19,22,29] This acceleration could be explained by tooth dehydration,[6] when light and heat are applied to the tooth surface.[13] However, in this systematic review, although a favorable trend was observed with the use of light-activated bleaching, no significant difference was observed compared with non-light-activated bleaching in the immediate, short-term, and medium-term effect. Even with this subgroup analysis, the results showed heterogeneity. The main reason for this effect could be different

bleaching protocols, concentrations of the bleaching products and the type of light used.

Most of the studies analyzed immediate tooth color changes, whereas only four studies followed up after more than 4 weeks. Considering that ADA guidelines stipulate that at least 50% of patients followed up for 3-6 months after treatment should maintain perceptible color changes,[33] more studies are required to evaluate tooth color bleaching stability in the medium term.

It is important to emphasize that this study only included RCTs. However, even if these are controlled clinical studies, which are the best scientific evidence for a systematic review, it is important to note a limitation due to high heterogeneity attributed to the different in-office bleaching procedures. According to Kossatz and others,[16] it is difficult to compare color change following in-office bleaching due of the different measurement methods (subjective and objective) and units (CIE-Lab system and shade guide scales), material concentrations, and techniques used.

Many studies use the Vita Classic Guide (subjective method) to measure color[23] or an objective method such as spectrophotometric guides;[5,27] both techniques are considered acceptable.[5,13] All included studies that evaluated tooth color changes used a subjective method, whereas only four studies used an objective method. This could be due to the wide use of the Vita Classical in clinical dental practice[12,13] and is the reason subjective measurements were used for color change meta-analyses.

One of the most commonly reported side effects of tooth bleaching is tooth sensitivity[6,20] and was therefore one of the outcomes evaluated in this study. Tooth sensitivity after in-office light bleaching procedures may occur as light absorbed by the bleaching gel and the resultant energy produces heat.[16] The tooth sensitivity outcome was evaluated after bleaching treatment for all the included studies through a visual analogue scale.

Regarding incidence of sensitivity, there were no differences observed between the groups analyzed. This suggests that sensitivity is not related to the light source but rather the bleaching gel concentration,[20] considering that bleaching gel increases enamel and dentin permeability and enhances the ability to achieve the pulp chamber[34] causing significant cell damage.[35]

Hydrogen peroxide gel concentration could have a significant role in tooth sensitivity. Agents with low concentrations are more tolerable by patients.[21] Apparently, with low concentration gel, light does not influence the sensitivity.[24,25,27] In the high-concentration gel, some studies have verified that the LED/laser systems can favor the reduction of sensitivity[4,6,]; on the other hand, some studies reported that light influence was worse [16,17,19] or did not influence.[5,20,21,23,24] Only one study compared the influence of different gel concentrations and the use of light and did not verify any differences between different gel concentrations on sensitivity.[24] However, this study focused on the influence of light sources during in-office tooth bleaching. Subgroup analyses were not carried out, given the small number of studies compared. Studies comparing bleaching gel concentrations should be developed and analyzed.

The second null hypothesis was accepted, because it was observed that light activation bleaching decreases sensitivity compared with non-light activation bleaching techniques. However, it was observed that a high heterogeneity and a single study had a great influence on the result.[4] Two facts can affect this result: the light used and the time of exposure to bleaching gel. The light source used was a LED/laser unit and the result can be explained by analgesic[37] and anti-inflammatory effect of this hybrid light. The infrared laser wavelength can promote a high polarization of the nervous membrane, minimizing incidence and the intensity of the sensitivity.[37] However for Farhat and others,[38] the LED-laser source did not prevent or reduce sensitivity. Another reason for this result was the reduction of the bleaching gel contact time with the dental structure with the light bleaching group. For all studies analyzed, the time of bleaching gel tooth surface contact was the same or very close. However, for this study, the time of bleaching gel contact, for the light group, was one half that of the non-light group. Trindade and others[35] affirm that the degree of damage is higher when increasing concentration and application time of the bleaching agent.

The dental literature is very contradictory concerning incidence of tooth sensitivity. Many studies showed a high sensitivity intensity when the light was used.[14,19] This can be explained by the high concentration of peroxide penetrating the tooth structure, which causes direct activation of a pulp neuronal receptor[22] and, along with the power intensity of the light source used,[17,21] may increase tooth temperature.[23] A temperature increase of 5.55°C compromises tooth vitality in 15% of dental pulps.[39] The use of a light source should not be considered when higher concentrations of hydrogen

peroxide are used and not be justified due to the risks involved.[40]

Sensitivity analyses were always performed with short-term follow-up. Only three studies evaluated sensitivity after one week, and only one study evaluated sensitivity over 30 days. This suggests that the greatest pain intensity occurs within the first hours of bleaching.[20,23]

Due to the risk of bias analyses, it is important to emphasize that fewer studies had complete information about sequence generation and allocation concealment. It is important that randomized controlled trials present methodologies explicitly so that data can be extracted and interpreted clearly. Another limitation of this study was the differences in bleaching protocols (number of bleaching sessions, number of gel applications per sessions). Thus, it is recommended that studies are developed with convergent methodologies.

CONCLUSION

In our meta-analyses, bleaching with light and non-light activation showed no differences in tooth color changes or tooth sensitivity incidence. However, light activation bleaching decreased the intensity of tooth sensitivity. Thus, the use of lights for in-office bleaching is not imperative in achieving the desired esthetic clinical results.

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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.

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