















Review

Efficacy of Carbamide and Hydrogen Peroxide Tooth Bleaching Techniques in Orthodontic and Restorative Dentistry Patients: A Scoping Review

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Citation: Malcangi, G.; Patano, A.; Inchingolo, A.D.; Ciocia, A.M.; Piras, F.; Latini, G.; Di Pede, C.; Palmieri, G.; Laudadio, C.; Settanni, V.; et al. Efficacy of Carbamide and Hydrogen Peroxide Tooth Bleaching Techniques in Orthodontic and Restorative Dentistry Patients: A Scoping Review. *Appl. Sci.* **2023**, *13*, 7089. <https://doi.org/10.3390/app13127089>

Academic Editor: Gabriele Cervino

Received: 8 May 2023

Revised: 7 June 2023

Accepted: 12 June 2023

Published: 13 June 2023



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Abstract: Background: Dental aesthetic procedures aim to rectify flaws in dental elements' shape, alignment, or overly dark color. One of the most common dental aesthetic procedures is tooth whitening. This study attempts to introduce key aspects of bleaching and describe the different techniques and the mechanism of action of bleaching agents, focusing on the clinical implications in orthodontic and on composite restorations. Methods: The research was performed on PubMed, Web of Science, and Science Direct databases for articles on our topic published between 2017 and 2023, and we found a total of 1512 studies. In total, 57 papers were considered for the qualitative analysis in the review. Results: This study found that both carbamide peroxide and hydrogen peroxide were clinically effective, although patients' level of tooth sensitivity seemed to be lessened by the latter. However, the latter appears to be more effective at reducing patient-experienced tooth sensitivity. Conclusion: Carbamide and hydrogen peroxide based whitening techniques were shown to be equally successful at treating tooth discoloration after bracket composite removal, with no discernible differences between them. To increase the effectiveness of whitening on composites, more research is needed. To achieve the desired results and avoid the negative effects of whitening gels on teeth and soft tissue, a patient-specific approach is advised.

Keywords: carbamide peroxide; composites; dental bleaching; hydrogen peroxide; orthodontics; tooth bleaching; tooth restorations; tooth sensitivity

1. Introduction

Aesthetics is becoming increasingly important in our society today. The growing attention to aesthetics inevitably also involves the care of the smile, thanks to the models proposed by magazines, social media, and social networks. It is essential that the aesthetics of the smile, although subordinate to function, meets the patient's expectations [1,2].

Aesthetic dental treatments are aimed at resolving imperfections related to the shape, incorrect position, or excessively dark color of dental elements. For this reason, tooth whitening has found wide popularity, becoming one of the most popular and successful aesthetic treatments [3].

Tooth discoloration can be divided into intrinsic and extrinsic. Intrinsic discoloration is due to age (yellowing of dentine due to wear), genetics, post-traumatic formation abnormalities, fluorosis, antibiotics, and systemic diseases such as hepatitis. The intrinsic color of a tooth depends on how light is scattered and absorbed on the surface and within the tooth structures. Enamel does not completely cover the color of the underlying dentine, which therefore plays an important role in determining tooth color. It also has a certain porosity that makes it penetrable to particles capable of changing the color of the enamel and dentine itself. Extrinsic discoloration, on the other hand, is due to environmental factors such as smoke, food pigments, amalgam, endodontic cement, and restorations: colored composites can be absorbed in the acquired film or on the tooth surface, resulting in pigmentation [4–6].

Food and smoke particles bind much more with mature plaque and tartar than with enamel, which is why extrinsic pigmentations can be removed by the abrasive action of an ultrasonic scaler and controlled by good oral hygiene [7–9].

Modern bleaching systems are based on peroxides, namely hydrogen peroxide (HP) and carbamide peroxide (CP), that can be applied to or within the tooth. Oxygen penetrates the dental tissues and breaks up the large pigment molecules, making them shorter and uncolored, also resulting in desaturation of the yellow shade. However, the treatment is not recommended for children under the age of 14 and for pregnant or lactating women. After treatment, one should avoid food, colored drinks, and smoking for at least 24 h [10–12]. Nowadays, common concerns of patients relate to discoloration. Patients request a dental visit precisely because they are dissatisfied with their teeth color are therefore more interested in dental aesthetics. It is known how this problem has an impact on the patient’s social life, affecting their self-esteem and behaviors such as laughing, talking, and showing teeth without embarrassment [13].

The treatment option for this type of problem is tooth bleaching. The dentist or hygienist during patient history must identify all patients who are contraindicated to dental bleaching treatment. The principal contraindications of bleaching are prosthetic rehabilitation, pregnancy, diabetes, respiratory disease, photoreactive drugs, and allergy to peroxides (Table 1).

Table 1. Contraindications of dental bleaching.

Pregnancy and Breastfeeding	If There Is Acute Hypersensitivity, Patient Cannot Take NSAIDS
Age < 18 years old	Pulp chamber larger and therefore closer to enamel. Increased incidence of hypersensitivity.
Diabetes and xerostomia-inducing drugs	Home bleaching is not recommended because it may decrease salivary flow. In-office bleaching is recommended.
Allergies to polymers contained in the mask	Avoid the home one with a mask and opt for the in-office one.
PUVA (psoralen and UV radiation) therapy or other types of photochemotherapy	Unable to use UVA lamp to photoactivate bleaching agent. Contact treating physician.
Therapy with photoreactive drugs or substance (antibiotics, contraceptives)	Unable to use UVA lamp to photoactivate bleaching agent. Contact treating physician.
Immunosuppressive therapies	Contact treating physician.
Oncologic patients	Contact the oncologist.
Respiratory deficiency	Difficulty in prolonged use of protective barriers and mouth openers, especially in the supine position.

The purpose of this review is to introduce key aspects of bleaching and describe the different techniques and the mechanism of action of bleaching agents, focusing on the clinical implications in orthodontic patients and composite restorations.

2. Materials and Methods

2.1. Protocol and Registration

This review was conducted in accordance with the guidelines for Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) literature searches [14], and it was submitted to PROSPERO with a temporary number (391265).

2.2. Search Processing

We conducted searches in PubMed, Web of Science, and ScienceDirect to find articles that addressed our issue that were published between 2017 and 2023. The following Boolean keywords were incorporated into the search strategy because they perfectly matched the aim of our investigation, which primarily focuses on the characteristics of various peroxide types, their applications, positive and negative effects, and the maintenance of the result over time: (“dental bleaching” AND “peroxide”); (“tooth bleaching” AND “peroxide”) (Table 2).

Table 2. Database search indicators.

	KEYWORDS: A: “peroxide”; B: “dental bleaching”; C: “tooth bleaching”
Articles screening strategy	Boolean Indicators: (“A” AND “B”); (“A” AND “C”) Timespan: 2017–2023
	Electronic Database: Pubmed, Web of Science, and ScienceDirect

2.3. Inclusion and Exclusion Criteria

The inclusion criteria were: (1) studies only on humans; (2) studies only in vivo; (3) studies only in English; (4) open access studies; (5) clinical trials or case reports; and (6) studies relating to the use of HP and CP and their comparison, their impact on composite restorations, and their use in orthodontics.

2.4. Data Processing

Author disagreements on the choice of articles were discussed and settled.

3. Results

The electronic database search identified a total of 1512 studies (PubMed n = 752, Web of Science n = 404, and ScienceDirect n = 356) from the electronic searches, resulting in 1202 studies that remained after removing 310 duplicates. In total, 892 articles were excluded because of the title and abstract analysis. The last 310 reports were successfully obtained and after passing the retrieval stage; 253 publications in all had their discussion requests denied because off-topic; and 57 papers in all were considered in the review for qualitative analysis (Figure 1).

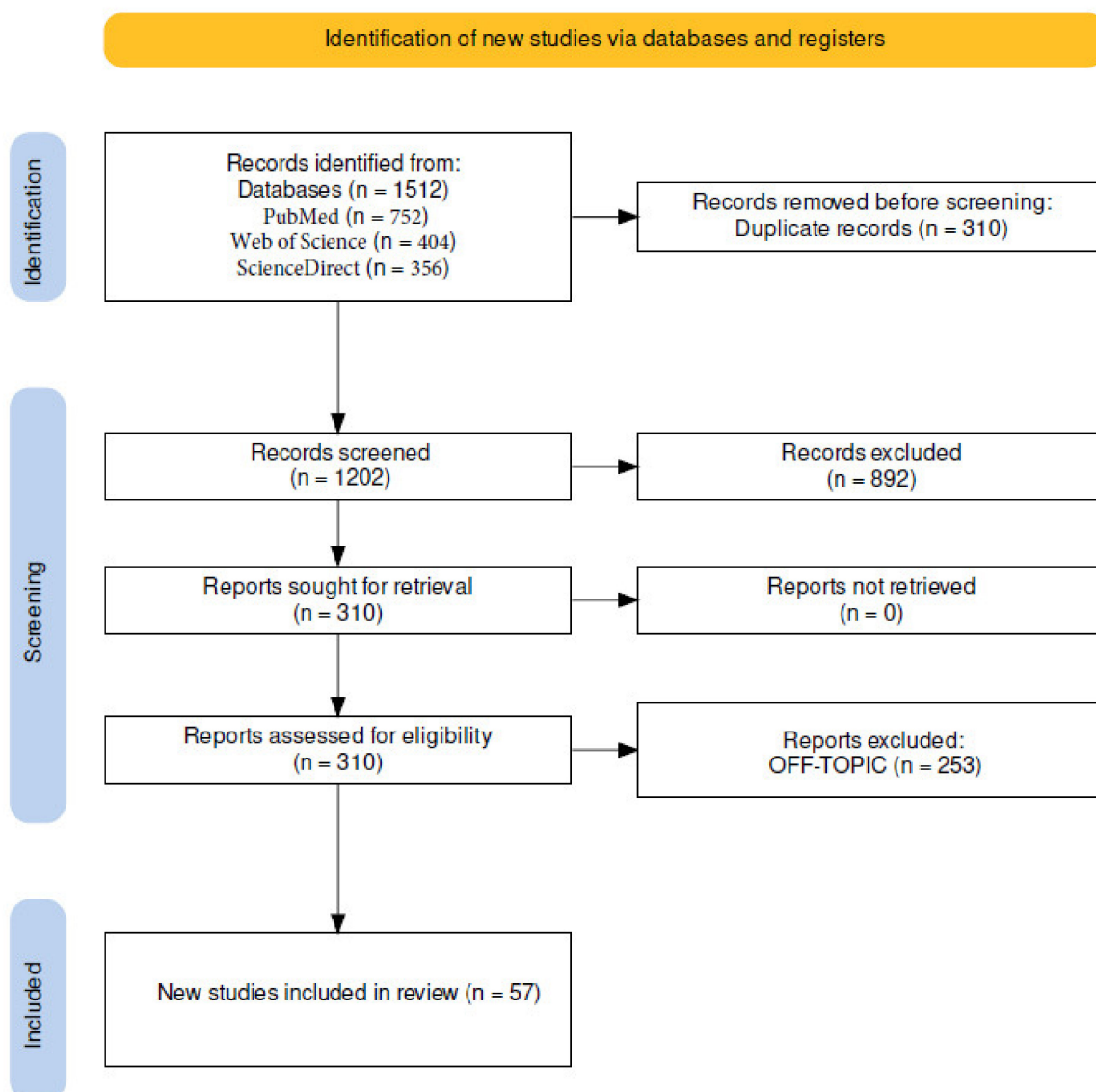


Figure 1. Identification of studies via databases and registers (PRISMA flow-chart).

4. Discussion

Today's most popular bleaching agents for both vital teeth and teeth subjected to root canal treatments are HP and CP, whose primary mechanism of action is based on their ability to oxidize the pigment molecules that cause discoloration [15]. In the following paragraphs, the different techniques of bleaching followed by the clinical implications in orthodontic and restorative dentistry are described.

4.1. Bleaching with Carbamide Peroxide

Tooth bleaching with CP is widely used in dentistry. For at-home bleaching treatment, the 10% CP concentration is regarded as the gold standard because of its extensive usage in at-home bleaching and the literature's extensive documentation of its efficiency and safety [16].

The CP can penetrate the enamel and dentin because of its low molecular weight. The primary mechanism by which the whitener works is by the oxidation of organic chemicals found in the tooth structure, which produces carbon dioxide and water. They release oxygen and free radicals when they come into contact with hard tissues, which oxidizes the pigments. The liberated oxygen permeates the dentinal tubules and acts by splitting the

complex, highly colored carbon ring chains into smaller chains, creating the appearance of lighter structures [17].

When 37% CP was administered, increased gingival aggression and tooth sensitivity (TS) was anticipated. However, both may be lessened by reducing the daily usage time [16].

The tooth whitening with 37% CP used for 30 min each day exhibited an equivalent whitening effect to that of 10% CP used for 4 h each day, without increasing TS or causing gingival irritation. Therefore, using 37% CP for 30 min each day can be a practical solution to shorten the time needed to utilize a bleaching tray for at-home tooth whitening [16].

It has been also shown that there are no differences between trays whether reservoirs are present or not [18].

Some studies have pointed out that the quality of life and aesthetic impression of patients did not change significantly after using 10% CP at-home; however, a reduction of psychological distress was noticed [17] (Table 3).

Table 3. Reported studies about bleaching with carbamide peroxide (CP).

Authors	Type of Study	Aim of the Study	Materials	Results
Sutil E. et al., 2022 [15]	Randomized, blind clinical trial	To compare the effects of 10% versus 37% CP on gingival irritation, TS, and bleaching effectiveness.	Eighty patients were chosen based on inclusion and exclusion standards, and randomly divided into two groups (n = 40): 37% CP and 10% CP.	At 1–3 weeks, the 37% CP group demonstrated quicker whitening than the 10% group. Although both groups displayed equal bleaching one month after the conclusion ($p = 0.06$).
Tavarez R.-R.-D.J. et al., 2021 [16]	Clinical study	To assess how at-home bleaching with 10% CP affected patients’ perceptions of their appearance and quality of life.	A total of 107 patients between the ages of 18 and 38 who had at least one anterior tooth in color A2 or darker were chosen. Patients who have undergone any kind of bleaching operations in the past were not eligible. Each patient received a 10% CP at-home bleaching treatment. The patients complied the OHIP-14 and OASIS questionnaire before and after the treatment.	Although there was a drop in the domain of psychological discomfort and an increase in worries about dental appearance, at-home bleaching with 10% CP had no appreciable effect on patients’ quality of life or aesthetic impression.
Martini E.C. et al., 2021 [17]	Clinical study	To assess the color change stability and patient satisfaction following a year of at-home bleaching with 10% CP in trays with or without reservoirs.	Forty-six patients underwent CP bleaching with a bleaching tray with or without reservoirs for three hours each day for 21 days. The color was measured using a spectrophotometer and shade guide units (SGU) one month and one year after bleaching was finished. A 5-point Likert Scale questionnaire was used to gauge patient satisfaction.	The design of the bleaching tray has no impact on the 10% CP’s ability to bleach (Opalescence PF, Ultradent). Regardless of the bleaching tray design, patients were quite pleased with the results of the bleaching.

4.2. Bleaching with Hydrogen Peroxide

Hydrogen peroxide (HP) is an active agent widely used during the procedure of external tooth bleaching, both in professional and in at-home-administered products [19,20].

The mechanism of action of HP is based on complex oxidation that causes the release of active oxygen species and the breakdown of pigments located in enamel and dentin. The active oxygen species formed by HP can permeate through the enamel prisms and reach the dentin, breaking down organic molecules [21].

The smaller and lighter compounds derived from the decomposition of organic molecules are responsible for the reflection of less color resulting in a whitening effect [22]. However, clinical studies reported that HP could reach the pulp chamber, causing adverse side effects. Biochemical changes in the dentin–pulp complex in response to bleaching agents are responsible for TS [23,24]. In vivo studies demonstrated that HP could cause oxidative stress to human dental pulp cells, interfering with odontoblastic differentiation. The presence of peroxides and their subproducts could activate the TRPA1 channel (transient receptor potential cation channel with ankyrin domain-type), which is associated with pain. In the same study, the authors demonstrated that the ozone therapy associated with HP does not interfere with bleaching and can reduce the side effects [21]. A study by Barbosa et al. revealed that remineralizing pastes, based on casein phospho-peptide–amorphous calcium phosphate (CPP–ACP), in association with 35% HP bleaching gel, could promote a significant reduction of pulp inflammation after bleaching [25]. Direct contact with HP could induce genotoxic effects on oral mucosa cells and gingival irritation [26]. In vivo, studies showed an increase of cytotoxic biomarkers in saliva, directly related to nuclear and oxidative DNA damage of oral mucosa cells directly exposed to HP-based products. These data suggest that caustic side effects could be due to a cellular protective mechanism of gingival and lip mucosa cells [27].

Changes in the enamel micro-hardness and increasing surface roughness because of bleaching products are effects reported in the literature [28]. The diffusion of HP on the hard tissue could depend on the concentration and contact time [29].

Many alternative methods in conjunction with HP products have been proposed to increase the biocompatibility of bleaching therapy. Several bleaching systems, application protocols, contact time, and different concentrations of HP gels were compared to detect the efficacy in terms of color and the risk of TS.

A clinical trial on 78 patients, carried out by Chemin et al., revealed that 10% HP increased the intensity of TS rather than 4% HP concentrations during at-home bleaching [23]. The risk of TS appears higher for 35% HP than for 15% HP after in-office bleaching treatment, according to the study by Lima et al. [30].

A study by Terra et al. showed that 30 min/day of 4% HP trays at-home application whitened teeth similarly to the recommended 120 min/day application time and significantly reduced TS [31].

In-office bleaching performed by 38% HP gel applied under different time protocols did not show differences in terms of efficacy whether the bleaching agent was used in a 40-min application or two 20-min applications, according to the results by Martins et al. [29].

Based on the study by Kim et al., a strip system of 2.9% HP was significantly more effective than the paint-on-type during at-home treatment [26].

At-home dental bleaching performed with 10% HP gel applied on the lingual surfaces seemed to promote worse results in bleaching efficacy rather than the application of gel on buccal surfaces [19].

A clinical trial on twenty-eight patients was carried out to assess the 1-year color stability produced by the different pH of HP gels when used as in-office treatments. No significant differences were obtained between the applications of neutral and acid gels [32].

The use of LED/Laser irradiation on in-office dental bleaching did not show better results compared with the technique without a light source but seemed to give an advantage in the TS and in the activation time [33] (Figure 2).

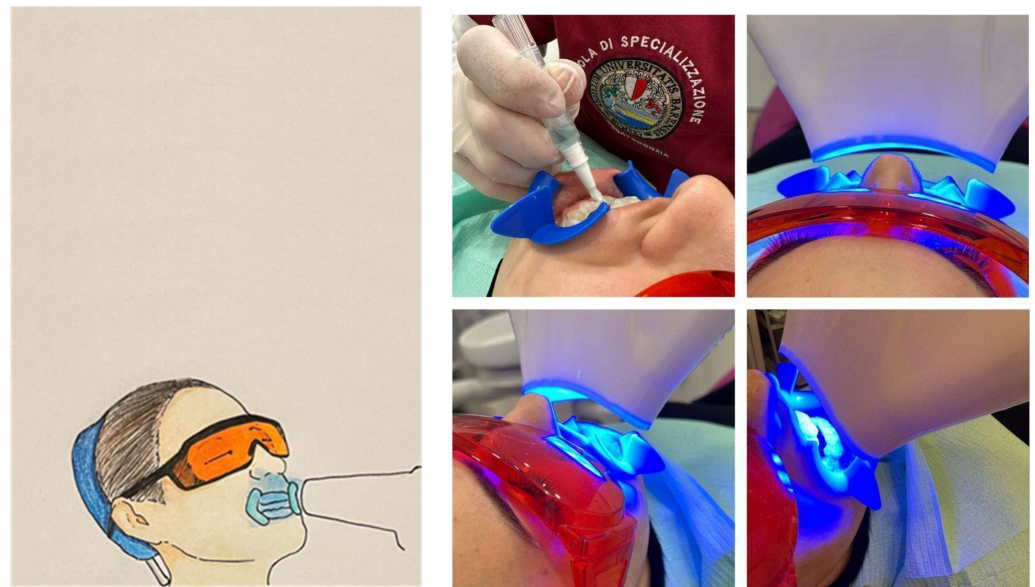


Figure 2. The use of LED/Laser irradiation on in-office dental bleaching.

Several studies point out the use of in-office 6% HP gel with nitrogen titanium dioxide (TiO₂) nanoparticles activated by LED/Laser source as efficient for dental bleaching. Bersezio et al. reported that there were no differences in the efficacy of a single application of 72 min of 6% HP with nitrogen TiO₂ nanoparticles or two applications of 36 min [34] (Table 4).

Table 4. Reported studies about bleaching with hydrogen peroxide [HP: hydrogen peroxide, IL: interleukine, TS: tooth sensitivity].

Authors	Type of the Study	Aim of the Study	Materials	Results
Estay J. et al., 2020 [19]	Randomized and prospective double-blind clinical trial	To compare the change, stability of color and effects on self-perception with 6% HP gel in an in-office bleaching relative to 37.5% HP gel.	Patients (n = 25) were assessed at 12 months post bleaching treatment: 6% HP chemo-activated alkaline formula gel versus 37.5% HP gel. Color changes were measured using Vita Bleached scale.	The effect of 37.5% HP was significantly better than that of 6% HP in terms of color rebound after 1 year of follow-up. The 6% HP achieved a positive psychosocial impact and enhanced self-perception at follow-up.
Tavares N.R.N.O. et al., 2021 [20]	Clinical trial	To evaluate the bleaching effectiveness and the physicochemical effects on enamel of violet light and ozone, associate or not to HP, compared to 35%-hydrogen peroxide.	Patients (n = 15): HP 35%, violet light, ozone, the association between hydrogen peroxide with ozone or violet light. All protocols were performed in two sessions with a 48 h interval. Color (spectrophotometer) and mineral composition (Raman spectroscopy) were measured before and after the bleaching.	Violet light associate with HP was unable to improve the color changes observed for the peroxide alone, in combination with ozone and HP. The ozone therapy improved the bleaching effect in the group that received the association of HP.

Table 4. Cont.

Authors	Type of the Study	Aim of the Study	Materials	Results
Monteiro D. et al., 2017 [21]	Clinical trial	To evaluate the effect of surface treatments and waiting time prior to contact with dye on bleached enamel staining susceptibility.	Patients (n: 100): bleached with 35% were in contact with red wine. Color difference was evaluated with a spectrophotometer. Surface treatments and waiting time effects were analyzed with Kruskal–Wallis and Mann–Whitney tests.	Surface treatments and waiting time were not significant to decrease bleached enamel susceptibility to red wine staining.
Chemin K. et al., 2018 [22]	Randomized, triple-blind clinical trial	To evaluate the risk for and intensity of TS and color change of at-home dental bleaching with 4% and 10% HP.	Patients (n = 78) into two groups: HP 4%, and HP 10%. At-home bleaching: 30 min twice a day for 2 weeks. The color was assessed by Vita Classical, Vita Bleached-guide and spectrophotometer Vita Easyshade at baseline, at first and second weeks and after one month. TS recorded by a numeric rating scale (0–4) and visual analogue scale (0–10).	Bleaching is effective with 4% and 10% HP concentrations, but 10% HP increased the absolute risk and intensity of TS.
Del Real García J.F. et al., 2019 [26]	Clinical trial	To evaluate the impact of 10% hydrogen peroxide whitening strip exposure on the genotoxicity and oxidative damage by means of the buccal micronucleus cytome assay by counting nuclear abnormalities (NAs) in buccal mucosa and attached gingiva cells and by analyzing in whole saliva the molecule 8-hydroxy-2'-deoxyguanosine (8-OHdG).	Patients (n = 113) were divided into: group 1 or control (n = 53), non-whitening strip exposed, and group 2 (n = 60), whitening strip exposed (Crest® 3D Whitestrips® premium plus, 10% hydrogen peroxide). Oral epithelial cells and whole saliva samples were taken at the beginning and 30 days later for group 1 and immediately before bleaching and 15 and 30 days after the end of the bleaching for group 2.	Individuals exposed to 10% hydrogen peroxide whitening strips exhibit NAs increased in oral epithelial cells and 8-OHdG in saliva. Individuals exposed to whitening strips with 10% hydrogen peroxide exhibit increased genotoxic and oxidative damage.
Youssef S.A. et al., 2021 [27]	Split-mouth randomized controlled clinical trial	To evaluate the effect of 35% HP gel renewal in association with violet LED (405–410 nm) through a split-mouth randomized controlled clinical trial.	Patients (n = 48) underwent 3 bleaching sessions of 15 min each, with an interval of 7 days between them, using 35% HP combined to violet LED irradiation. Teeth color was measured with VITA Classical scale and the spectrophotometer Vita Easyshade. TS was measured using a Visual Analog Scale before, immediately after each bleaching session, and 14 days and 60 days after the end of the treatment.	There is no need for bleaching gel renewal when following the clinical protocol of 3 sessions of 15 min in a bleaching protocol of 35% HP combined with violet LED.

Table 4. Cont.

Authors	Type of the Study	Aim of the Study	Materials	Results
Martins I. et al., 2018 [28]	Multicenter, single-blind, randomized trial	To evaluate the bleaching efficacy and TS of in-office 38% HP applied under different time protocols.	<p>Patients (n = 45) with right superior canines darker than C2 were selected.</p> <p>The 38% HP was applied in two 20 min (2 × 20) applications or one 40 min (1 × 40) application.</p> <p>Color changes were evaluated by using Vita Classical and Vita Bleached guide and Easyshade Spectrophotometer methods at baseline and 30 days after the second session.</p> <p>TS was recorded up to 48 h with a 0–10 Visual Analogue Scale.</p>	The use of a 40 min in-office bleaching agent gel application produced the same whitening degree and TS that the two 20 min bleaching agent applications did.
Lima S.N.L. et al., 2018 [29]	Randomized double-blind clinical trial	To compare TS, bleaching efficacy, and cytokine levels after applying in-office bleaching treatments containing 15% and 35% HP.	<p>Patients (n = 25) were randomly assigned to receive HP15% or HP 35% treatment.</p> <p>The bleaching agent was applied in three 15-min applications per session. Two bleaching sessions were separated by a 1-week interval.</p> <p>Gingival crevicular fluid was collected from three jaws sites per patient for the analysis of fluid volume. Flow cytometry was used to analyze gingival crevicular fluid levels of IL-1β, IL-2, IL-4, IL-6, IL-10, tumor necrosis factor, and interferon-gamma. All measurements were obtained before and after bleaching.</p>	Treatment with HP 35% is more effective than HP 15% but generates a greater risk and intensity of TS. No inflammatory changes occurred despite the difference in the HP concentrations.
Terra R. et al., 2021 [30]	Single-blind randomized clinical trial	To compare the risk/intensity of TS and color change of a 30 min vs. the recommended 120 min application time of 4% HP for at-home bleaching.	<p>Patients (n = 92) were divided into a group of 30 min vs. the 120 min application for at-home bleaching.</p> <p>Trays with 4% HP were used for 3 weeks.</p> <p>The color was assessed by Vita Classical, Vita Bleached guide 3D-MASTER and spectrophotometer Vita Easy shade at baseline, weekly, and after 1 month.</p> <p>TS was recorded by a numeric rating scale (0–4) and visual analogue scale (0–10).</p>	A 4 week protocol of at-home dental bleaching with 4% HP for 30 min/day whitened teeth similarly to the 120 min/day protocol, with low intensity of TS and high patient satisfaction.

Table 4. Cont.

Authors	Type of the Study	Aim of the Study	Materials	Results
Bersezio C. et al., 2019 [23]	Double-blind randomized clinical trial	To evaluate the bleaching efficacy produced by two HP gels with different pHs, at 1 year since treatment.	Patients (n = 28) into two groups and four subgroups. The treatment was assessed during and after the bleaching procedure up to 12 months post-treatment. The color was assessed by two bleaching scales shade guide units and spectrophotometer device.	Bleaching using a neutral (pH = 7.0) in-office gel demonstrated similar stability and rebound effect than an acidic one (pH = 2.0).
Mondelli R. et al., 2018 [32]	Randomized, triple-blinded, and split-mouth clinical study	To evaluate effectiveness of a hybrid light source on the color change, stability, and TS in patients submitted to different in-office bleaching techniques.	Patients (n = 20) into four groups: 35% Lase Peroxide Sensy (LPS) + hybrid light; 35% HP+ hybrid light; 35% HP; 25% LPS + hybrid light; 25% HP + hybrid light; and 35% Whiteness HP: 35% HP. For the groups activated with hybrid light, the HP was applied on the enamel surface three consecutive times using a 3 × 2 min protocol (three hybrid light activations for 2 min each, with a 30 s interval for a total of seven minutes and 30 s) for each gel application. For the other groups, HP was applied 3 × 15 min. The color was assessed by a spectrophotometer device.	All techniques and bleaching agents were effective on bleaching during a 36 month evaluation of color stability. The groups activated with HL presented lower TS and required a lower activation time.
Bersezio C. et al., 2021 [33]	Clinical trial	To compare the effectiveness and TS of in-office dental bleaching with one versus two applications of 6% (HP) gel with nitrogen titanium dioxide nanoparticles activated by LED/Laser lamp in a single session.	Patients (n = 27) were treated in office with 6% HP with nitrogen titanium dioxide nanoparticles. Group 1 received one application of 72 min and Group 2 received two applications of 36 min.	There were no significant differences in the effectiveness of a single session with one or two applications of 6% HP with nitrogen titanium dioxide nanoparticles between both groups.
Angel P. et al., 2018 [34]	Clinical trial	To evaluate the bleaching efficacy and impact on psychosocial and aesthetics self-perception of 6% HP gel compared with a conventional 37.5% HP gel when used as an in-office treatment.	Patients (n = 35) received two sessions of three 12 min applications of treatment with 37.5% HP on one side of the mouth and 6% HP on the other. Color changes were measured objectively using total variation in color and subjectively using the Vita Classical scale. Aesthetic questionnaires were administered to measure self-perception.	Low concentration of HP achieved effective bleaching with good stability at 3 months accompanied by a positive psychosocial impact and enhanced self-perception. However, the traditional 35% concentration was objectively more effective.

Table 4. Cont.

Authors	Type of the Study	Aim of the Study	Materials	Results
Ferraz N.K.L. et al., 2019 [35]	Randomized, parallel, and double-blinded clinical trial	To evaluate the impact on the oral health-related quality of life of in-office dental bleaching using low-concentration hydrogen peroxides.	Patients (n = 54) were divided into using 6% or 15% HP in-office bleaching activated via hybrid LED/laser light. Color changes were measured objectively using total variation in color and subjectively using the Vita Classical scale.	Both agents showed bleaching effectiveness but HP 15% presented greater color stability than HP 6%, at the 6 month follow-up. The agents showed low levels of TS, gingival irritation, and did not affect the oral health-related quality of life of the participants.
Trevisan T.C. et al., 2022 [36]	Double-blinded clinical trial	To evaluate the clinical performance of dental bleaching performed with 6% HP containing TiO ₂ -N nanoparticles exposed to blue and violet activation lights.	Patients (n = 40) were randomly distributed into four experimental groups (n = 10): 35% HP (PH35)-control; 6% HP (PH6) containing TiO ₂ -N nanoparticles without light activation; PH6 activated with a blue LED (PH6A); and PH6 activated with a violet LED (PH6V). The three bleaching sessions consisted of 3 consecutive 16 min applications of the bleaching agent described for each group. The groups receiving LED activation were exposed to light intermittently every 1 min, with a total exposure time of 8 min in each application.	All groups treated with 6% HP were less likely to cause TS compared to the control group (PH35). The use of PH6 activated by LED violet resulted in an effective and safe clinical protocol for in-office dental bleaching.
Bersezio C. et al., 2019 [37]	A split-mouth study	To evaluate color longevity after 2 years of whitening gel (6% HP), blue LED/infrared laser activation system) in comparison to a control 35% concentration.	Patients (n = 31) were treated using 6% or 35% HP gel. The color was measured at baseline and 1 week, 1 month, and 1 and 2 years after treatment using the Easyshade Vita spectrophotometer and the Vita Bleached and Vita Classical Shade Guides.	The positive effect of bleaching on quality of life was maintained in patients treated with a low concentration of the whitening gel.

4.3. Comparison between the Use of Carbamide Peroxide and Hydrogen Peroxide

In a 6 month follow-up study conducted in 2017, Aka and Celik examined the bleaching efficiency of two at-home bleaching systems using preloaded trays with 6% HP and custom trays with 10% CP on teeth of varied colors [38].

Ninety-two patients were randomly assigned to one of three groups: no bleaching agent application (control group), patients treated with a custom-made tray containing 10% CP (10% CP/PF) (Opalescence PF), and patients treated with a pre-loaded tray containing 6% HP (6% HP/Go) (Opalescence Go). The color values were assessed at the beginning, after 10 and 14 days, and after 6 months of bleaching. When compared to the control group, both bleaching systems were clinically effective and produced higher bleaching efficacy [39].

The 10% CP/PF showed higher bleaching efficacy than the 6% HP/Go; the higher bleaching efficacy of 10% CP/PF may be related to the longer application duration despite its lower HP concentration [39].

Ana Rita Barcessat et al., analyzed the dental color stabilization of upper incisors and canines in 60 patients undergoing different bleaching techniques: group 1 (35% HP in-office bleaching), group 2 (in-office application of 3% HP followed by in-office bleaching using 35% HP), group 3 (3% HP in-office bleaching), and group 4 (10% CP at-home-bleaching) [40].

Differences in canine's chroma were noted in a short-term evaluation (after the 3rd session for groups 1, 2, and 3, and 7 days after at-home bleaching): in group 1 and group 2, canine's chroma was significantly lower than in group 4. However, lightness increased in all groups with no statistical difference 60 days after treatment [40]

Concerning TS, it is strongly linked to the presence of peroxides and their reaction products reaching the pulpal chamber causing an inflammatory response [41]. As a result of the lower concentration of HP available, CP can be used to reduce TS (Figure 3).

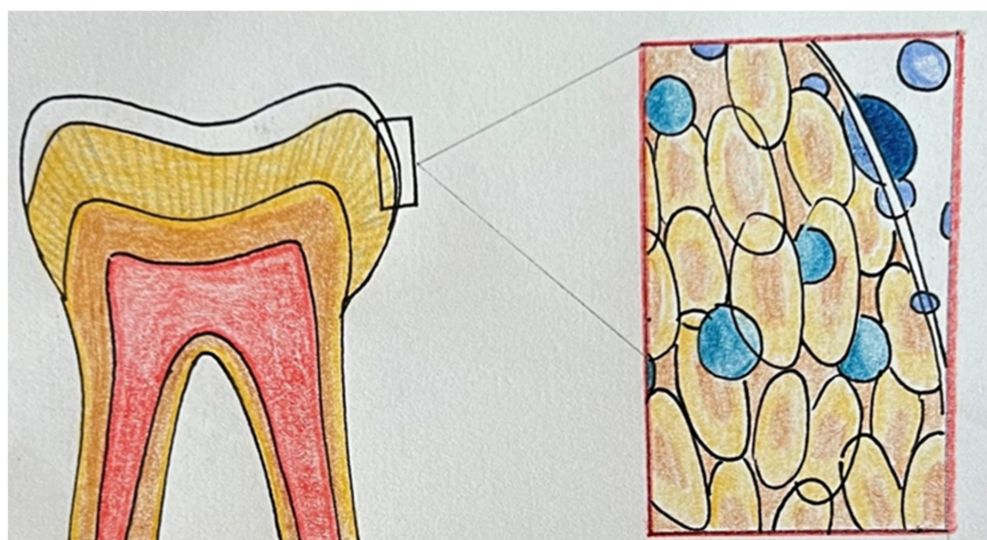


Figure 3. Chemical mechanism of bleaching systems.

Peixoto et al., compared the effectiveness of whitening and its effect on TS of two different at-home bleaching techniques: 37% CP and 35% HP [41].

The results of this clinical study demonstrated that when used in a single 40 min in-office application, high concentrations of CP (37%) effectively achieve satisfactory bleaching effects [41].

Despite producing less color change than 35% HP, 37% CP reduced significantly both the risk and level of TS experienced by patients [41].

HP and CP are used in high concentrations for endodontically treated teeth (non-vital teeth) [42].

Cristian Bersezio et al. evaluate the psychosocial impact and aesthetic perceptions of 42 patients undergoing non-vital tooth bleaching with HP (35%) and CP (37%). The color change (ΔE) has been evaluated at 1 week, 1 month, and 3 months after bleaching [42].

The results of the current study demonstrate that both gels were highly effective, and the color change lasts at least three months [42] (Table 5).

Table 5. Reported studies about comparison between the use of carbamide peroxide and hydrogen peroxide [CP: carbamide peroxide, HP: hydrogen peroxide, TS: tooth sensitivity].

Authors	Type of the Study	Aim of the Study	Materials	Results
Celik E.U. 2017 [38]	Randomized controlled clinical trial	Compared the bleaching efficacy of two different at-home bleaching systems (10% CP and 6% HP).	Ninety-two patients were chosen and randomly divided into three groups: negative control, 10% CP, and 6% HP.	Although both bleaching agents were clinically effective, 10% CP was more successful.
Peixoto A.C. et al., 2018 [41]	Single-blinded randomized parallel clinical trial	Evaluate TS in patients undergoing in-office tooth bleaching with 37% CP and 35% HP.	Forty patients were randomly assigned to receive two sessions of in-office tooth whitening using either 35% HP or 37% CP. The degree of TS for each patient was assessed before, and up to 24 h after bleaching.	37% CP resulted in reduced TS.
Bersezio C. et al., 2018 [42]	Randomized clinical study	Evaluate the psychosocial impact and aesthetic perceptions of 42 patients undergoing non-vital-tooth bleaching with HP (35%) and CP (37%).	Forty-seven patients were chosen and divided into two groups according to the bleaching agent used: group 1 (35% HP) and group 2 (37% CP).	Both gels were highly effective, and the color change lasts at least three months.
Barcessat A.R. et al., 2018 [39]	Clinical trial	Evaluate dental color stability after various bleaching techniques.	Sixty patients were divided into four groups: 35% HP in-office bleaching, in-office application of 3% HP followed by in-office bleaching using 35% HP, 3% HP in-office bleaching, and 10% CP at-home bleaching.	All techniques produced higher bleaching efficacy.

4.4. Comparison between In-Office and At-Home Dental Bleaching

The use of low bleaching agent concentrations (10–16% CP or 6% HP) applied for at least two weeks is indicated for at-home bleaching [41].

For in-office procedures, bleaching agents (HP 25–40% or CP 35%) are applied for shorter amounts of time with or without light activation [41].

It can be performed at-home or in-office with a wide range of techniques. At-home-bleaching treatment tray-based system uses trays built on an impression and prepared in the laboratory, the bleaching gel is placed inside the trays and used for a few hours during the day or overnight for a few days (from two to three weeks) [42,43] (Figure 4).



Figure 4. Home bleaching, trays built.

On the other hand, in-office bleaching is performed chairside and uses a bleaching gel with higher concentrations of hydroxide placed on the tooth for minutes, activated by an LED light [18] (Figures 5 and 6).



Figure 5. (a) Dental bleaching in dental clinic with a liquid dam is an advantage to avoid gingival tissue irritation. (b) Before the treatment, and (c) after the treatment.



Figure 6. Clinical case of bleaching before and after the treatment.

Different bleaching protocols based on HP and CP concentrations have been proposed in the literature [44]. The classic at-home-bleaching was described by Chemin in 2018. He used a bleaching gel containing 10% calcium hydroxide inside trays using for 30 min, twice daily for 2 weeks. After one month of follow-up, the bleaching was significant [45]. Maran and Fraga Briso proposed an at-home bleaching protocol with a 10% HP gel containing a desensitizing gel (3% potassium nitrate and 0.2% sodium fluoride) inside it. The authors compared it with a gel of the same HP concentration but without desensitizer. Both were used for 3 h a day for 21 days. There was no difference reported in either TS or color [46,47]. In addition, Martini stated that the presence of a reservoir in a bleaching tray did not influence the effectiveness of the treatment, TS, and gingival irritation [48]. Sutil compared two at-home techniques using bleaching gels (10% versus 37% CP). Both were used for 3 weeks. The first group (CP 10%) used it for 4 h a day, and the second group (CP 37%) used it for 30 min a day. The result was the same. Therefore, the authors suggest using bleaching gel containing a higher percentage of CP but took less time to use [16]. The most widely used protocol for at-home bleaching is described by López Darriba. He used low concentrations of CP (10%) overnight [49]. The same author in another study compared the same concentration of CP (10%) for 14 and 21 days and he deduced that 3 weeks is the best duration to obtain good bleaching [50]. Vildósola et al. showed in-office bleaching mode. In his study, he compared a concentration of HP (6%) with an application of 36 min for a session versus 3 applications of 12 min for a session. The authors proved the moderate efficacy and similar TS [51]. Ermis, in his study, suggested that the efficacy of treatment is affected by tooth decalcification and the trayless system type, while the trayless system influenced the duration of the treatment [52]. Piknjač's used 40% HP for 3 applications every 20 min in a single session and showed the significant efficacy of the bleaching over the 6 month follow-up period [52]. Matteo Kury used a purple LED without any bleaching gel and he obtained a good long-term result (with a follow-up of 6 to 12 months) [53]. Saeger Meireles showed how in-office bleaching using 37.5% HP in two sessions of 8 min

allowed the same degree of bleaching with less TS than 3 sessions of 8 min [54]. Vaez proposed the combination of both techniques: 35% HP in office for 45 min and 10% CP for 1 h at-home, reducing the time needed for satisfactory treatment but increasing TS [55]. In Mayer Santos' work, a hybrid treatment is proposed using 35% HP with different modes of use (between at-home and in-office bleaching) with effective treatment and less TS [56,57].

In conclusion, both bleaching techniques are effective. Specifically, in-office-bleaching uses a high concentration of molecules (HP and CP) obtaining immediate treatment but with high TS. On the other hand, at-home-bleaching uses low concentrations obtaining lower TS but equal or even higher bleaching efficacy [58]. The prolonged treatment can cause gingival irritation due to the over-edge of the gel over trays; this is difficult to obtain in-office bleaching with the use of a liquid dam [59,60]. Mounika and Rodrigues, in their experimental studies, did not find a significant difference in efficacy between in-office or at-home bleaching [61]. In addition, some authors combine the two techniques to determine higher efficacy and lower TS [62]. It is recommended to assess the patient's needs and choose the best treatment for each patient, avoiding the worsening of the tooth and soft tissue health due to the side effects of bleaching gels [63] (Table 6).

Table 6. Reported studies about comparison between in office and at-home dental bleaching [CP: carbamide peroxide, HP: hydrogen peroxide, TS: tooth sensitivity].

Authors	Type of the Study	Aim of Study	Materials	Results
Chemin K. et al., 2018 [22]	Randomized clinical trial	Evaluate the effectiveness of home bleaching treatment with 10% HP.	Twenty volunteers. At-home bleaching (30 min twice a day, for 2 weeks).	Follow-up after a month, a significant bleaching.
Mounika A. et al., 2018 [43]	Randomized clinical trial	Comparison between two techniques: 35% HP + 16% CP.	Thirty patients. At-home bleaching (16% CP) and in-office bleaching (35% HP).	Effective treatment for both procedures and color regression at 3 and 6 months follow-up.
Rodrigues J.L. et al., 2018 [60]	Randomized clinical trial	Comparison between two techniques: 38% HP and 10% CP (in-office and at-home bleaching).	Forty patients. In-office bleaching and second session of home bleaching or in-office bleaching.	No difference in bleaching efficacy and TS was found between performing a second session in the study and combining with 1 week of home bleaching.
Maran B.M. et al., 2018 [45]	Randomized, triple-blind clinical trial	Comparison between two techniques: 10% CP with desensitizer gel (3% potassium nitrate and 0.2% sodium fluoride) and a 10% CP gel without desensitizer.	Sixty patients. At-home bleaching (3 h a day for 21 days).	No difference in bleaching efficacy and TS.
Ermis R.B. et al., 2018 [51]	Randomized clinical trial	Comparison between techniques: 1. 10% CP, 2. bleaching membrane with 10% HP, 3. tray applied bleaching membrane with 10% HP and bleaching pen with 22% CP.	Ninety patients divided into two groups: lighter and darker teeth. The teeth in each group were further divided into three groups (n = 15).	The severity of tooth discoloration and the type of trayless system affected the effectiveness of bleaching, while only the type of trayless system affected color stability.

Table 6. Cont.

Authors	Type of the Study	Aim of Study	Materials	Results
Vildósola P. et al., 2017 [50]	Randomized clinical trial	Comparison between two techniques of in-office bleaching: 6% of HP.	Thirty patients. In-office bleaching in 2 modes: 1 application of 36 min versus 3 applications of 12 min, each for 2 sessions.	No difference about TS. Both reported slight TS.
Vaez S. et al., 2019 [55]	Randomized, controlled clinical trial	Comparison between at-home and in-office bleaching 10% CP and 35% HP.	Twenty-six patients in-office bleaching for 45 min with 35% HP and at-home bleaching for 1 h/day with 10% CP.	The combined protocol reduced the time necessary to obtain a good effectiveness with at-home bleaching but increased the risk of TS.
Mayer-Santos E. et al., 2022 [56]	Randomized, controlled clinical trial	Comparison between at-home and in-office bleaching with 35% HP.	One-hundred participants divided into 4 groups: G1 35% HP (4 sessions, 1 a week); G2 LED violet (4 sessions, 1 a week); G3 LED violet (4 sessions, 2 a week); G4 hybrid technique (LED violet + 35% HP; 4 sessions, 1 a week).	The hybrid technique showed excellent bleaching with lower TS.
Piknjač A. et al., 2021 [52]	Randomized, controlled clinical trial	Comparison between in-office and at-home bleaching: 40% HP, 16% CP, and 10% CP.	Sixty participants divided in 3 groups: 1. 40% HP in-office, 2. home bleaching 16% CP, 3. home bleaching 10% CP.	Same bleaching efficacy but with lower TS of home bleaching with 10% CP compared to home bleaching with 16% CP and in-office bleaching with 40% HP.
López Darriba I. et al., 2017 [48]	Randomized clinical trial	Comparison of at-home bleaching techniques: 10% CP and 7.5% HP.	Eighty participants divided into 4 groups: (1) 10% CP/1 h a day; (2) 10% CP/ overnight; (3) 7.5% HP/1 h a day; (4) 7.5% HP/overnight.	The most effective protocol is low concentrations (10% CP) with overnight use.
Martini E.C. et al., 2020 [17]	Split-mouth, single-blind, randomized, controlled equivalence trial	Comparison between bleaching with or without reservoirs with 10% CP.	Forty-six patients divided into 2 groups: bleaching trays were made with reservoirs and the other half, without reservoirs.	The presence of reservoirs in a bleaching tray did not improve bleaching or determine TS and gingival irritation.
Silva L.M. et al., 2022 [18]	Randomized clinical trial	Comparison of the use of HP in different tooth surfaces.	Twenty-five patients divided into 2 groups: 10% HP once daily for 60 min to the buccal surface (BSB) and 10% HP once daily for 60 min to the lingual surface (LSB).	No significative differences.

Table 6. Cont.

KnezovićZlatarić D. et al., 2019 [57]	Randomized, controlled trial	Comparison of at-home bleaching techniques: 6% HP and 16% CP.	Thirty participants divided into two groups: 1. 15 received hybrid treatment in-office bleaching (6% HP + 2 weeks at-home bleaching with 16% CP); 2. 15 in a control group.	The hybrid treatment is the most effective.
Darriba I. et al., 2019 [49]	Randomized clinical trial	Comparison of different protocols using 10% CP.	Fifty participants divided into 2 groups: (A) with a 14 day treatment and (B) with a 21 day treatment.	Daytime application of at-home bleaching for 3 weeks achieves better bleaching results than 2 weeks, immediately after treatment and 1 and 6 months later.
Briso A.L.F. et al., 2018 [46]	Randomized clinical trial	Comparison of power bleaching 10% CP with and without potassium oxalate.	Twenty-five patients. Power bleaching 10% CP with potassium oxalate was utilized and 10% CP without potassium oxalate for 3 weeks.	No difference in TS.
Sutil E. et al., 2022 [15]	Randomized, blind clinical trial	Comparison of at-home bleaching techniques: 10% versus 37% CP.	Eighty patients divided into 2 groups. At-home bleaching: 1. 4 h/day for 10% group, 2. 30 min/day for 37% group; both for 3 weeks.	Same results but with less treatment time with 37% CP.
Dourado Pinto A.V. et al., 2019 [59]	Randomized clinical trial	Comparison of at-home and in-office bleaching techniques: 10% HP and 40% HP.	Seventy-five patients divided into 3 groups: (a) at-home-bleaching 10% HP for 15 days/ 1 h a day; (b) office bleaching 40% HP, 3 sessions of 40 min); (c) combined: a session with 40% HP and the other sessions with 10% HP for 15 days.	At-home and combined techniques may cause greater TS than office-technique and lead to a higher gingival irritation.
Kury M. et al., 2022 [53]	Randomized clinical trial	Comparison of in-office bleaching techniques CP and HP.	One-hundred patients divided into 5 groups: LED, CP, LED/CP, HP, and LED/HP.	The use of purple LED alone (without bleaching gels) produced perceptible long-term bleaching results.
Piknjač A. et al., 2021 [52]	Randomized, controlled clinical Trial	The effectiveness of in-office bleaching with 40% HP.	Twenty participants, 40% HP, 3 applications each 20 min, in one session.	Significant results during 6 months of follow-up.

Table 6. Cont.

Meireles S.S. et al., 2021 [54]	Randomized, controlled clinical trial	Comparison of in-office bleaching techniques using 37.5% HP.	Forty participants divided into 2 groups: 1. 2 applications (37.5 HP2) 2. 3 applications (37.5 HP3)/8 min for sessions. Three clinical sessions were performed with an interval of 1 week.	No significant differences.
Donassollo S.H. et al., 2021 [58]	Randomized, controlled clinical trial	Comparison of at-home and in-office bleaching techniques: 35% HP (in-office) and 10% CP (at-home).	One-hundred-and-thirty volunteers divided into 2 groups: (a) in-office bleaching and a placebo at-home protocol; (b) in-office placebo and at-home bleaching treatment.	The 10% CP produced a superior effect compared with 35% HP and TS were similar for the 2 techniques.
Féliz-Matos L. et al., 2019 [64]	Randomized, double-blind clinical trial	Comparison of at-home bleaching techniques: 10%/15%/20% CP and 40%/10% HP.	One-hundred-and-twenty participants divided into four groups of treatment were defined: G1 = CP 10% + HP40%, G2 = CP15% + HP40%, G3 = CP20% + HP40%, G4 = HP10% + HP40%.	The result was similar (bleaching and TS).
Mailart M.C. et al., 2021 [62]	Randomized clinical trial	One comparison of at-home bleaching techniques: 10% HP and 10% CP.	Sixty participants. Opalescence GO (OGO)-10%HP PT-30 min, White Class-10%HP CT-30 min, Opalescence PF-10%CP CT-2 h, e Opalescence PF-10%CP CT-8 h.	No significant difference.
Pereira R. et al., 2022 [13]	Randomized controlled trial	Comparison of at-home bleaching techniques: 6% HP and 16% CP.	Eighty participants. Group A—in-office 6% HP paint-on varnish; group B—at-home 6% HP with adaptable tray; group C—at-home 16% CP with a custom tray.	No significant difference at 6 months of follow-up after treatment.

4.5. Effect of Dental Bleaching in Orthodontic Treatment

Bleaching during and after orthodontic treatment was investigated in vivo only in a few articles and must be examined more.

Levrini et al. demonstrated that at-home bleaching using orthodontic aligners or thermoformed bleaching trays with reservoirs was equally effective using spectrophotometry. In this study, a finite element analysis reported that the distribution of 2 m³ of gel at the center of the vestibular surfaces of teeth is sufficient to distribute it to all the vestibular surface while wearing aligners [63,65].

The association between at-home dental bleaching with 10% CP and the removal of bonded material leftovers using a super fine, tapered diamond bur followed using an enamel micro abrasion product after orthodontic bracket debonding is shown in the clinical case reports by Pavani et al. [65,66].

The suggested procedure significantly enhanced aesthetics and successfully eliminated grooves left behind when the bonding composite was removed, leaving a smooth enamel surface.

Gomes reported two case reports of in-office bleaching treatment conducted using two or three 40 min sessions using 35% HP. The teeth were successfully bleached despite the presence of brackets fulfilling patients' expectations of straightened and whitened teeth [66].

In a randomized clinical trial of Ahrari et al. investigating different bleaching techniques on patients a maximum of three months after fixed multibracket appliance removal, the individuals were divided into four groups according to the way of bleaching [67]. While individuals in group 1 got at-home bleaching, patients in groups 2 through 4 underwent in-office bleaching utilizing a diode laser, a plasma arc, and no light source, respectively. At-home bleaching resulted in a positive color change. Laser-assisted bleaching should be regarded as the finest alternative among in-office procedures because it delivered effective outcomes with the least amount of TS and in the shortest amount of time [68] (Table 7).

Table 7. Reported studies about the effect of dental bleaching in orthodontic treatment.

Authors	Type of the Study	Aim of the Study	Materials	Results
Ahrari F. et al., 2020 [67]	Randomized clinical trial	To analyze the effectiveness and risks of various whitening techniques in patients with stained teeth who have undergone orthodontic treatment.	Sixty volunteers (31 women, 29 men) aged 14 to 30 years randomly divided in 4 groups: group 1 underwent bleaching at-home, whereas those in groups 2 through 4 underwent bleaching in-office using, respectively, a diode laser, a plasma arc, and no light source. Tooth color was measured at baseline, an hour after the bleaching process was complete, and one week afterwards. A record was kept of the degree of post-treatment problems and TS.	All methods were effective in managing tooth discoloration after orthodontic treatment. Laser-assisted bleaching should be regarded as the finest alternative among in-office procedures because it delivered effective outcomes with the least amount of TS and in the shortest amount of time.
Levrini L. et al., 2020 [63]	Finite element analysis, clinical study	To evaluate the teeth whitening performance of trays without reservoirs using clinical research using spectrophotometry and a finite element analysis (FEA).	Three sample areas of gel application on the maxillary central incisors (the incisal edge, the middle part, and the gingival edge) were analyzed. A spectrophotometry was used to ascertain the clinical effectiveness of the bleaching gel as it related to the results of the FEA. The chromatic variation obtained by the bleaching gel on teeth 41 and 32 (control teeth, with reservoirs) was compared with that on teeth 31 and 42 (study teeth, without reservoirs).	Optimal gel distribution is reached when 2 mm ³ of gel is applied to the center of the vestibular face of the tooth in the tray. No relevant differences of whitening effectiveness between the teeth with reservoirs and those without.
Pavani C.C. et al., 2021 [65]	Case report	To evaluate the improving in esthetics after orthodontic brackets debonding.	One patient undergoing at-home bleaching with 10% HP, fine bur removal of composite, and micro abrasion after orthodontic brackets removal.	The proposed treatment considerably improved the esthetics and successfully removed the grooves created during the removal of the bonding composite, resulting in a smooth enamel surface.
Gomes M.N. et al., 2017 [66]	Case report	To evaluate teeth whitening while receiving orthodontic treatment.	Two patients undergoing two or three 40 min sessions while wearing fixed orthodontic braces.	Despite the braces, the teeth were successfully bleached.

4.6. Effects of Dental Bleaching on Composite Restorations

In the literature, the effect of bleaching on composites has been evaluated in a few randomized controlled trials, which examined mainly microhybrid resins and nanocomposites. Composites are resin-based monomeric materials, which have now replaced metal and amalgam, in dental restoration procedures after caries removal. Composites are made up of two or more materials useful to provide more performing characteristics or to add additional functionality to the original components [69–71]. With the development of micro/nano-science and technology, other filling materials and natural minerals in various shapes and sizes have been added to the traditional composite resins made of quartz filler and strontium or barium glass, resulting in an improvement in mechanical qualities [70]. The materials used as filler in nanofilled are Zirconia/Silica and nanosilica, while hybrid composite resin is a combination of macrofilled and microfilled [72,73].

The randomized controlled clinical trial of Elhoshy et al. analyzed the effect of 15% CP bleaching gel for at-home use on two types of composite resin restorations, namely nanocomposite and microhybrid. The parameters evaluated when taking digital photographs are color patterns, opacity, and fluorescence. At 2 weeks, microhybrid composites show superiority in terms of color patterns. On the other hand, the mean opacity and fluorescence values show no statistically significant differences [72].

Mereiles et al. also evaluated the at-home bleaching procedure with 10% CP in a randomized controlled trial on anterior maxillary teeth. The parameters analyzed this time was color changes and TS, comparing decayed teeth and non-decayed teeth at week 2 after whitening. The authors concluded that there is a lower degree of whiteness in teeth that had undergone a restoration compared to healthy ones. On the other hand, regarding TS being the most frequent side effect of a bleaching procedure, they did not detect any statistically significant difference [74] (Table 8).

Table 8. Reported studies about effects of dental bleaching on composite restorations.

Authors	Type of the Study	Aim of the Study	Materials	Results
Elhoshy A.Z. et al., 2018 [72]	Randomized controlled trial	To evaluate the effect of 15% CP at-home bleaching on nanocomposite and microhybrid resins.	Sixty class V cavities in maxillary premolars. Teeth were divided in 4 groups: Group A (control): 15 specimens, light nanocomposite resin (Filtek Z350 XT) with no post-restoration bleaching procedure (control); Group B (experimental): 15 specimens, light nanocomposite resin (Filtek Z350 XT) with post-restoration bleaching procedure; Group C (control): 15 specimens, restored with microhybrid resin (Filtek Z250 XT) with no post-restoration bleaching procedure; Group D (experimental): 15 specimens, restored with microhybrid resin (Filtek Z250 XT) with post-restoration bleaching procedure.	After 2 weeks of bleaching, there was superiority of microhybrid composites for color patterns. No differences in mean opacity and fluorescence values.
Meireles S.S. et al., 2010 [74]	Randomized controlled trial	To evaluate color change and TS after 10% CP at-home bleaching in sound and restored teeth.	Forty patients divided in 2 groups. Group A: 20 patients with 6 caries-free maxillary anterior teeth), and Re Group B: 20 patients with at least 1 restoration in the 6 maxillary anterior teeth.	After 2 weeks of bleaching, lower color change in restored teeth. No differences for TS.

From these works, it can be assumed that it is not rational to change the type of restoration after a bleaching procedure in the absence of aesthetic problems and that it may be necessary, after bleaching, to replace the restorations to achieve better aesthetic results.

5. Conclusions

The use of CP at 37% increases gingival inflammation and TS, and exhibits an equal effect to that of 10%. HP could damage the dentin–pulp complex causing pain and TS and shows a cytotoxic effect on the oral mucosa. To increase the biocompatibility of HP, many alternatives have been proposed as different concentrations and time protocols, or the association with LED irradiation, which do not demonstrate significant amelioration. Regarding the comparison of the two systems, the investigation revealed that both gels were clinically effective although CP seems to reduce the level of TS in the patients. No significant differences between at-home and in-office bleaching have been found, and the combination of both techniques improves the efficacy, also reducing the time needed for satisfactory treatment. Concerning at-home bleaching, the addition of a desensitizing gel does not report benefits in either TS or color and the presence of a reservoir in the tray does not influence the results. Orthodontic aligners could be used as a tray for this technique. It has been demonstrated that after orthodontic treatment, the teeth were successfully bleached, and all methods seem to be effective in managing tooth discoloration after the removal of the bracket's composite. The efficacy of bleaching on composites needs further research to be improved; however, at the current state, microhybrid composites seem to show superiority in terms of colors compared to nanocomposites.

A tailored approach is advised to evaluate each patient's needs and select the best protocol to obtain the required outcomes and prevent the adverse effects of bleaching gels on the tooth and soft tissues.

Author Contributions: Conceptualization, A.D.I., A.M.I., G.M., F.P., A.P. and C.D.P.; methodology, A.M.C., G.P., E.X. and E.d.R., software, A.M.C., G.G., V.S., F.I. and G.D.; validation, E.X., G.M., I.R.B., A.P., D.D.V., F.P., V.S., F.I. and G.D.; formal analysis, A.D.I., F.P., A.P., A.M.C., I.R.B., D.D.V., F.I. and G.D.; resources, A.D.I., A.M.I., G.M., C.D.P., C.L. and S.B.; data curation, G.M., I.R.B., G.G., F.I. and G.D.; writing—original draft preparation, A.D.I., A.M.I., E.d.R., S.B., C.L., G.P., G.L., E.X., V.S., D.D.V., E.X., F.I. and G.D.; writing—review and editing, A.P., A.M.C., G.P., E.d.R., I.R.B. and S.B. visualization, G.P., C.D.P., G.L., F.I., A.P., V.S. and I.R.B.; supervision, A.D.I., A.M.I., F.P., G.M., D.D.V., F.I. and G.D.; project administration, G.G., C.L., I.R.B., F.I. and G.D. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

CP	Carbamide peroxide
CPP–ACP	Casein phospho-peptide–amorphous calcium phosphate
FEA	Finite element analysis
HP	Hydrogen peroxide
SGU	Shade guide units
TiO ₂	Nitrogen titanium dioxide
TS	Tooth sensitivity

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