MAINTENANCE OF DENTAL BLEACHING: A SYSTEMATIC REVIEW

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Abstract: After bleaching procedure, color pigments can adhere to the rough dental surface and can trigger more discoloration. In this sense, no standard post-bleaching maintenance technique exists. The purpose of this study was to evaluate the maintenance of enamel color after bleaching procedure through a systematic review.
The research question was defined as follows: Is the tooth whitening maintenance necessary after a bleaching treatment? Two reviewers conducted the literature search in PubMed (MEDLINE), Web of Science, Scopus, EMBASE, and SciELO. Both in vitro and clinical trials reporting the color change of bleached enamel after the use of a tooth whitening agent were included in the review. The risk of bias in the included manuscripts was evaluated using the RoBDEMAT tool.
A total of 11 articles were included in the qualitative analysis. Due to the lack of groups for comparison, a meta-analysis could not be conducted. The whitening maintenance procedures identified were remineralizing agents, antioxidants, over-the-counter agents, toothpaste containing Blue Covarine, casein phosphopeptide-amorphous calcium phosphate fluoride paste, 0.05% sodium fluoride mouthwash, arginine, nano-hydroxyapatite, nano-carbonate apatite, and CO_2 laser.
In conclusion, tooth whitening maintenance could be achieved by using some agents. The association of these agents might be beneficial for maintaining the color of the enamel throughout 12 months following bleaching procedure.

Keywords: bleaching; color; over-the-counter bleaching products; remineralization.

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ENTRETIEN DU BLANCHIMENT DENTAIRE: UNE REVUE SYSTÉMATIQUE

Résumé: Après la procédure de blanchiment, les pigments de couleur peuvent adhérer à la surface dentaire rugueuse et provoquer davantage de décoloration. En ce sens, il n'existe aucune technique standard d'entretien après blanchiment. Le but de cette étude était d'évaluer le maintien de la couleur de l'émail après une procédure de blanchiment à travers une revue systématique.
La question de recherche a été définie comme suit: l'entretien du blanchiment dentaire est-il nécessaire après un traitement de blanchiment? Deux évaluateurs ont effectué la recherche documentaire dans PubMed (MEDLINE), Web of Science, Scopus, EMBASE et SciELO. Des essais in vitro et cliniques rapportant le changement de couleur de l'émail blanchi après l'utilisation d'un agent de blanchiment des dents ont été inclus dans la revue. Le risque de biais dans les manuscrits inclus a été évalué à l'aide de l'outil RoBDEMAT.
Au total, 11 articles ont été inclus dans l'analyse qualitative. En raison du manque de groupes de comparaison, une méta-analyse n'a pas pu être réalisée. Les procédures d'entretien du blanchiment identifiées étaient des agents reminéralisants, des antioxydants, des agents en vente libre, un dentifrice contenant du Blue Covarine, une pâte de fluorure de phosphate de calcium amorphe de phosphopeptide de caséine, un bain de bouche au fluorure de sodium à 0,05 %, de l'arginine, de la nano-hydroxyapatite, de l'apatite de nano-carbonate et Laser CO2.
En conclusion, l'entretien du blanchiment des dents pourrait être réalisé en utilisant certains agents. L'association de ces agents pourrait être bénéfique pour maintenir la couleur de l'émail pendant les 12 mois suivant l'intervention de blanchiment.

Mots clés: blanchiment ; couleur; produits de blanchiment en vente libre; reminéralisation.

Introduction

Esthetic appearance has risen in importance recently due to its effect on, social, psychological, and personal relationships. Teeth color is a major determinant factor for patients' contentment and self-confidence [1]. Thus, when a single tooth doesn't match the color of the other teeth, the consequences can be more pronounced, especially at a social level where people are judged based on their appearance [2].

Bleaching, both external and internal, has become one of the most demanded treatments in dentistry because of its conservative and minimal invasive approach [3, 4]. In this technique, gels with hydrogen peroxide (HP) or carbamide peroxide (CP) are used and their application systems differ based on the concentration of the active ingredient, which bleaches the tooth by oxidation-reduction reactions of the free radicals [5]. It is important to highlight that three main dental bleaching approaches exist: at-home bleaching with supervision; in-office dental bleaching; and at-home, over-the-counter (OTC) bleaching agents such as strips, mouthwash and toothpaste [6]. The first two methods rely on the action of the free radicals from the reaction of HP or CP with the dental structure [7, 8]. Yet, the free radicals might cause antagonistic reactions during the bleaching operation [9-12], including postoperative tooth hypersensitivity, pulp damage, altering the enamel topography, or gingival irritation [12-14]. The action of OTC products is mostly based on two processes: bleaching of intrinsic stains by means of oxidizing agents in order to break down the organic molecules present in the dental structure, and the elimination and control of extrinsic stains through abrasive agents.

In-office bleaching techniques utilize high concentrations of HP gels when compared to at-home bleaching, usually ranging between 25% and 40%. This is done to provoke a whitening effect in the anterior region [15]. Typically, home bleaching uses a low relative level of HP or CP at night and is applied for at least 14 days [8]. OTC bleaching agents usually have low levels of HP, varying between 3% and 6% and are self-applied to the teeth once or twice daily for up to 2 weeks depending on the exposure duration and dosage [7].

Numerous ways existed to evaluate the efficiency of a bleaching product, embracing the use of shade tabs, digital or mobile photography, spectrophotometers, colorimeters, and computer dental digitization [16-18]. To quantify the optical features of teeth, the most useful tool was specifically the CIELAB system [19]. Having said that, bleached teeth presented higher L* values, however, a lower b* values. The a* value seem to be moderately unaltered [20-22].

A previous survey was conducted in 2015 and demonstrated that tooth bleaching remains the normally demanded dental cosmetic treatment, including 32% of all treatments intreated [23], preserving freshly bleached teeth color merits attention as well. Specifically, patients might experience dental color rebound in as little as 60 days, appropriately, attention concerning the maintenance of bleaching results is generally stated [24-27]. These people can be further apt to ask about maintenance by means of professionally suggested home-care approaches. Certain patients might select to increase perfected tooth color following dental bleaching and return once or twice/year for touch-up conservation protocol at the dental office, though others who favor home oral hygiene-based approaches might elect to use of powered toothbrushes, since the effectiveness of this protocol to remove more stain and plaque, when compared to manual toothbrushes alone [28, 29]. Other agents available into market for bleaching, include OTC such as bleaching toothpastes, strips, and mouthwashes [30]. These agents might be insufficient when compared to home-bleaching [31]. But, due to their capability in stain removal, they can be an alternate for color maintenance following whitening, supervised by a dental clinician [32]. Additionally, fluoridated bleaching gels, nano-carbonate apatite, or fractional CO_2 laser might support post-bleaching maintenance effect by inducing remineralization fluoride acquisition of enamel, or preventing stain absorption [33].

Following bleaching procedure, color pigments adhere to the rough dental surface and can trigger more discoloration when compared to the original tooth. In detailed, a rough enamel surface with superficial defects after these modifications can be simply discolor [34]. For these intentions, it is crucial that the impaired enamel surface must be recovered next bleaching for a long-lasting bleaching outcome. Further, apart from the above report and to the extent of the researchers' knowledge, no standard post-bleaching maintenance technique has so far been decisive for clinicians for better color stability of bleached enamel. The purpose of this study was to evaluate the maintenance of enamel color after bleaching procedure through a systematic review. Accordingly, the null hypothesis was that the use of agents for bleaching maintenance would produce no difference on the color of bleached enamel.

Materials and Methods

This study followed the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA Statement) and conducted a systematic review and meta-analysis [35]. The registration protocol was performed in Prospero (registration number: CRD42023437927). The study employed the PICOS framework, focusing on the population (bleached enamel), intervention (Tooth whitening maintenance.), control (No tooth whitening maintenance.), and outcome (color difference). The research question was defined as fol-

lows: Is the tooth whitening maintenance necessary after a bleaching treatment?

Search Strategy

Two independent reviewers (RB and CECS) conducted the literature search on June 8th 2023, utilizing several databases such as PubMed (MEDLINE), Web of Science, Scopus, EMBASE, and SciELO. The search strategy employed the terms outlined in Table 1. All identified studies were imported into the Rayyan QCRI mobile app.

Eligibility Criteria

The title and abstract of each article were reviewed by RB and ED to determine their inclusion for full-text review. The following eligibility criteria were applied: (1) in vitro studies or clinical trials reporting the color change of bleached enamel after the use of a tooth whitening agent, (2) included a control group where maintaining agents were not applied, (3) evaluated the color difference, (4) included mean and standard deviation data of Delta E, and (5) published in the English language. Exclusions consisted of case reports, case series, pilot studies, expert opinions, conference abstracts, and reviews. Disagreements in study selection were resolved through discussion and consensus with a third reviewer (LH).

Data Extraction

Data of interest from the included articles were extracted using Microsoft Office Excel 2016. Two reviewers (RB and ED) independently performed the analysis after receiving training in the software. The extracted data included study and year, type of study, bleaching type, follow up, maintenance procedures, color measurement, and main results.

Quality Assessment

Two reviewers (LH and WD) independently assessed the risk of bias in the included manuscripts using the RoBDEMAT tool. The evaluation focused on four domains: planning and allocation (D1), specimen preparation (D2), outcome assessment (D3), and data treatment and outcome reporting (D4). Each signaling question within these domains was answered using options such as "sufficiently reported," "insufficiently reported," "not reported," or "not applicable." The risk of bias findings was summarized in a table format, following the recommended approach of the RoBDEMAT tool. Instead of providing an overall summary risk of bias score, a basic checklist format was maintained.

Table 1. Search strategy used.

Search	Keywords
# 1	At-home bleaching OR Bleached teeth OR Tooth bleaching OR Tooth whitening OR Bleaching OR Vital bleaching OR Bleached enamel OR Bleaching agents OR carbamide peroxide OR hydrogen peroxide OR bleaching home
# 2	Bleaching effectiveness OR Color alteration OR Color change OR Staining power OR Intrinsic color OR Color stability OR Tooth discoloration OR Color measurement OR Tooth Color OR Color Shade OR dental color OR color perception OR color matching OR color accuracy
# 3	Post-bleaching OR dentifrice OR toothpaste OR color longevity OR Dental prophylaxis OR maintenance OR power toothbrush OR Strips OR Mouthwashes OR tooth bleaching agents OR toothpastes OR fluorides OR toothbrushing OR white strips OR tooth bleaching agents OR chewing gum
# 4	Controlled Clinical Trial OR Retrospective Studies OR Randomized Controlled Trial OR Retrospective Study OR Prospective Studies OR Prospective Study OR Clinical Trial OR Randomized clinical trial OR in-vitro OR in vitro OR Laboratory research
# 5	# 1 AND #2 AND #3 AND #4 AND #5

Results

A total of 3,361 papers were initially retrieved from all databases. After removing duplicates, 2,460 documents were screened based on their titles and abstracts. Following this screening, 17 studies remained for full-text inspection. Among these, 6 studies were excluded due to the unavailability of the full text of the manuscript [36-41]. Thus, a total of 11 articles were included in the qualitative analysis. Unfortunately, due to the lack of groups for comparison, a meta-analysis could not be conducted. The selection process according to the PRISMA statement is illustrated in Figure 1.

Table 2 presents the main characteristics of the studies included in the qualitative analysis. Both in-vitro and clinical studies were included in the review. Regarding whitening techniques, both in office and at-home techniques were tested. For in-vitro studies, a maximum of 1-year aging was evaluated, and for clinical trials, a maximum follow-up of 12 months was assessed. The maintenance procedures included: remineralizing agents, antioxidants, over-the-counter agents, toothpaste containing Blue Covarine, casein phosphopeptide-amorphous calcium phosphate fluoride paste, 0.05% sodium fluoride mouthwash, arginine, nano-hydroxyapatite, nano-carbonate apatite, and CO_2 laser.

Regarding the risk of bias assessment, the studies lacked reporting on parameters such as operator-blinded, sample size calculation, and statistical analysis (Table 3).

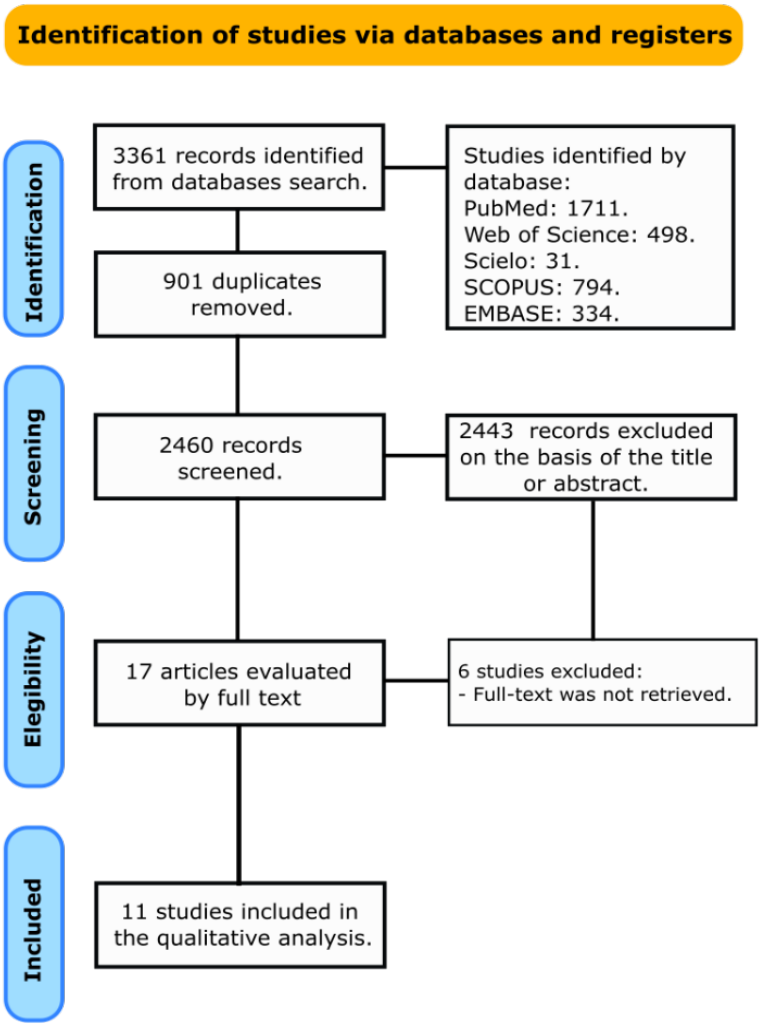

Figure 1. Selection process according to the PRISMA statement.

Table 2. Demographic and study design data of the included studies.

Study and year	Type of study	Bleaching type	Follow up	Maintenance procedures	Color measurement	Main results
Attin, 2007 [18]	In vitro	Home bleaching: 10% carbamide peroxide (CP) gels not on the market yet (Incos, Nieder-Olm, Germany)	1-7 days 8-12 days	Fluoridated 10% CP	Not tested	To reverse the hardness loss after bleaching, the fluoridated 10% CP gels could be beneficial

Bersezio, 2018 [4]	Randomized clinical study	Walking bleaching: 35% hydrogen peroxide (HP) (Opalescence Endo, Ultradent, United States) 37% CP (Whiteness Super- endo, FGM, Joinville, SC, Brazil)	Baseline, 1 week, 1 month, 6 months, and 12 months	The walking bleaching itself was considered here as maintaining agent	Vita EasyShade Compact (VITA Zahnfabrik, Bad Sa¨ ckingen, Germany)	Maintenace of the results after 1 year was efficient with the walking bleaching technique
Bortolatto, 2018 [43]	In vitro, randomized and blinded study	In office: 35% HP Home bleaching: 10% CP	Baseline, day 1, 7 days, and 14 days	Toothbrushing in an automatic brushing machine (MAVTEC - Comércio e Serviços e Desenvolvimento para Laboratório, Ribeirão Preto, Brazil) with a a toothpaste containing Blue Covarine	Vita EasyShade (Vident, Brea, USA)	Toothpastes comprising Blue Covarine do not display an enhancement in whitening teeth
Jiang, 2018 [44]	A double-blind randomized controlled clinical trial	In office: 40% HP gel (Opalescence BOOST PF 40%, Ultradent, South Jordan, UT, USA)	Baseline-prior to the bleaching treatment, immediately following the first bleaching session, immediately following the second bleaching session, and one week and 3 weeks after the end of the bleaching process	Crest 3D Whitening, Procter & Gamble, Blue (Ash, OH, USA) Close Up White Now (Unilever, Sa˜o Paulo, Brazil)	Vita Easyshade Advance 4.0 (Vita Zahnfabrik, Bad Sa¨ckingen, Germany)	Applying whitening dentifrices following bleaching procedure aids in maintaining the whitening outcomes

Kim, 2011 [45]	In vitro	Home bleaching: 10% CP (Opalescence 10%; Ultradent, South Jordan, UT, USA)	Baseline, and final	Nano-carbonate apatite	CM-3500d (Minolta, Tokyo, Japan)	10% nano-carbonate apatite might maintain the initial enamel color and keep the damaged enamel structure following bleaching
Lee, 2017 [15]	Clinical	In office: Philips Zoom WhiteSpeed Ultradent Opalesence Boost	Baseline, 7 days, 30 days, and 90 days	Philips Sonicare power toothbrush Manual toothbrush	VITA EasyShade device	The maintenance of tooth shade was better when using a power toothbrush
Malekipour, 2019 [46]	In vitro	Home bleaching: 20% CP (Ultradent Products Inc., South Jordan, Utah, USA)	Baseline, day 1, and after remineralizing agents' application	Casein phosphopeptide-amorphous calcium phosphate fluoride (CPP-ACPF) paste Remin Pro paste 0.05% sodium fluoride (NaF) mouthwash	ShadePilot (DeguDent GmbH, Rodenbacher, Germany)	Remin Pro is more appropriate than other solutions, and displayed the least post-bleaching discoloration potential
Moharam, 2022 [47]	A randomized controlled clinical trial	In office: Opalescence Boost 40% Tooth Whitening System (Ultradent Products, Inc., South Jordan, Utah, USA)	Baseline, immediately, 1 week, 2 weeks, and 3 weeks after bleaching	2.5% Arginine and nano-hydroxyapatite	VITAPAN classical A1-D4® shade guide (VITA Zahnfabrik, H. Rauter GmbH & Co., Bad Sa□ckingen, Germany)	Both maintaining agents were efficient
Moosavi, 2016 [33]	In vitro	Home bleaching: 15% CP (Opalescence, Ultradent Products, Inc, South Jordan, UT, USA)	Before and immediately after bleaching	Fluoride (NaF 2%, Dentscare Ltda, Duo Desense, Brazil) CO_2 laser Nanohydroxyapatite (Sigma Aldrich, 677418 DG, USA)	VITA Easyshade (VITA Zahnfabrik H Rauter GmbH & Co KG, Deasyas-79704, Germany)	Applying fluoride, fractional CO_2 laser, and nanohydroxyapatite for post bleaching process are proposed for prevention bleached enamel from stain absorption

Santana Jorge, 2019 [32]	In vitro	Home bleaching: whitening 22% CP	1 year	Over-the-counter agents	Easyshade, VITA (Bad Säckingen, Germany)	Over-the-counter agents such as Whitening toothpastes with the association of mouth rinses could be helpful for maintaining color throughout 1 year following bleaching procedure
Taneja, 2018 [42]	In vitro	In office: Pola office (SDI, Victoria, Australia)	During each bleaching session, 7 days, and 15 days	Remineralizing agent (Vantej toothpaste, India) Antioxidant: grape seed extract (Biovea, USA)	Photoreflectance spectrophotometer (UV-2450, Shimadzu Corp.)	The remineralizing agent performed better at all time intervals

Table 3. Risk of bias analysis.

Author	D1: Bias in Planning and Allocation			D2: Bias in Specimen Preparation		D3: Bias in Outcome Assessment		D4: Bias in Data Treatment and Reporting	
	Control group	**Randomization of samples**	**Sample size**	**Standardization of samples and material**	**Identical experimental conditions across groups**	**Adequate and standardized testing procedures and outcomes**	**Blinding of the test operator**	**Statistical analysis**	**Reporting study outcomes**
Attin, 2007 [18]	Reported	Reported	Not reported	Reported	Reported	Reported	Not reported	Reported	Reported
Bersezio, 2018 [4]	Reported	Reported	Reported	Reported	Reported	Reported	Reported	Reported	Reported
Bortolatto, 2018 [43]	Reported	Reported	Not reported	Reported	Reported	Reported	Reported	Reported	Reported
Jiang, 2018 [44]	Reported	Reported	Reported	Reported	Reported	Reported	Reported	Insufficiently reported	Reported
Kim, 2011 [45]	Reported	Reported	Not reported	Reported	Reported	Reported	Not reported	Insufficiently reported	Reported
Lee, 2017 [15]	Reported	Reported	Reported	Reported	Reported	Reported	Reported	Insufficiently reported	Reported
Malekipour, 2019 [46]	Reported	Reported	Not reported	Reported	Reported	Reported	Not reported	Insufficiently reported	Reported

Moharam, 2022 [47]	Reported	Reported	Reported	Reported	Reported	Reported	Not reported	Insufficiently reported	Reported
Moosavi, 2016 [33]	Reported	Reported	Not reported	Reported	Reported	Reported	Not reported	Insufficiently reported	Reported
Santana Jorge, 2019 [32]	Reported	Reported	Reported	Reported	Reported	Reported	Not reported	Insufficiently	Reported
Taneja, 2018 [42]	Reported	Reported	Not reported	Reported	Reported	Reported	Not reported	Insufficiently reported	Reported

Discussion

A systematic review was directed concerning the maintenance of bleached enamel after bleaching. Appropriately, most of the maintaining agents included in the study enhanced the damage of staining bleaching enamel. Suitably, the null hypothesis tested in this study was rejected.

Throughout or just following a bleaching session, tooth discoloration is reachable if pigments of beverages and food are consumed during that time. Thus, it was belived that freshly bleached teeth subjected to some surface treatments was an efficient approach to lessen the uptake of stains and keep the result of whitening for a long time [42].

Different possible approach existed to reverse the damage of staining enamel after bleaching: the use of antioxidant, remineralizing agents (toothpaste, CPP-ACP, Remin pro paste, NaF mouthwash), power toothbrush, OTC agents, fluoridated bleaching agent, CO_2 laser, nano-hydroxyapatite, and arginine.

One should keep in mind that applying an antioxidant such as grape seed extract (mainly proanthocyanidins) after tooth bleaching leads to less restraining potential [42]. This is due to the mineral deposition by the proanthocyanidins- collagen interaction, thus keeping the exposed collagen. Further, encourage the modification of the insoluble collagen into a soluble collagen. This confirmed the remineralization potential of this maintaining agent and its success during post-bleaching application [42].

With regards to remineralizing agents, the use of this agent in the form of toothpaste like Vantej (toothpaste, India) showed less tooth staining after bleaching [42]. One should bear in mind that Vantej is a Novamin containing bioactive glass which is considered a mineral component including calcium sodium phosphosilicate. This agent reacts with saliva inside the oral cavity, hence, elevating the pH. By doing so, calcium and phosphate precipitated as a layer and formed a hydroxycarbonate apatite [48]. These particles have appeared to liberate ions and remineralize the dental surface for up to 14 days, decreasing stain [49]. Additionally, different forms of remineralizing agents could be available like fluoride and CPP-ACP fluoride paste, known MI Tooth Mouse. It could be possible to use the CPP-ACP agent to overcome mineral loss and simultaneously with a bleaching product without impairing the bleaching outcome [50,51]. Further, Remin Pro paste is a novel remineralizing cream based on water and embracing Xylitol, hydroxyl- apatite, and fluoride, increasing the microhardness of dental structure following bleaching procedure [46]. In this manner, this agent acts similarly to GC brand Tooth Mousse product. The increase in microhardness is the high fluoride content in Remin Pro, which is 61% more than that of other brands like the GC Tooth Mousse Plus) [52,53]. So, this makes the clinician's choice about post-bleaching treatment by such a remineralizing agent questionable, as this could disappoint patients preferring a whiter smile. In addition, different formulations of peroxide adding to calcium and fluoride, demonstrated that calcium and/or fluoride prevented the reduction of enamel microhardness, and thus, recovering the post-bleaching state [54]. The CPP-ACP could cause dental hypersensitivity [55], so, when compared to NaF-containing fluoride gels, ACP-containing gels have a greater effect on the remineralization of pre-demineralized teeth regardless of this disadvantage [56]. NaF agent in form of solution exhibited a remarkable dental discoloration, then not advocated as a remineralizing agent. All in all, remineralizing agents tested in this systematic review perform in the same way, by decreasing the yellow color, and increasing the white color. Remin Pro revealed the smallest post-bleaching discoloration agent and is more appropriate than different solutions for maintenance [46].

Further, home oral care delivered by patients after bleaching could help in color maintenance. The use of powered toothbrushes is such an example [15]. It is trusted that a power tooth brushing is more predictable when compared to a manual tooth brushing for plaque and stains removal removing plaque and stains [57,58], similarly for maintenance of tooth

shade post-bleaching approach. In recent years, power toothbrushes have become marketable, however, resistance to their daily use existed since the harmful enamel effect and gingival recession. Previously, studies demonstrated that sonic, electric, or other powered toothbrushes, are safe on both enamel and gingival area as much as a manual toothbrush [28, 29]. Furthermore, regardless of toothpaste, the power brushing eliminated more stains on the tooth surface compared to manual tooth brushing [57]. Therefore, power tooth brushing produces a potential influence on the maintenance of bleached enamel color [58]. These findings matched the result of the present review, and add to the body of scientific evidence that power tooth brushing might aid in post-bleaching maintenance and prolonged the long-term tooth shade improvement [15].

It should be noted that OTC agents can be easily found in supermarkets and drugstores including bleaching toothpastes, strips, and mouthwashes [30]. These agents might remove stains in an efficient way and could help in color maintenance after whitening [32].

Concerning whitening toothpaste, the presence of numerous abrasive particles in its structure, might assist in color maintenance of enamel after bleaching [59]. Whitening effect was promoted by hydrated silica, alumina, or dicalcium phosphate found in whitening toothpaste. Beyond abrasive particles, other toothpastes with peroxide-containing formula endorsed a greater bleaching influence. Yet, the peroxide-free bleaching toothpastes produced greater effect than peroxide-containing formulas since the low concentration of the peroxide on toothpastes [32]. This urged researchers to develop a novel bleaching toothpaste which included a modified silica and a blue pigment called Blue Covarine [60,61]. The effect of bleaching based on Blue Covarine relies on modifying the optical effect of tooth color. A thin blue film on the enamel surface will be deposited and shifts the yellow axis to blue, thus providing the bleaching influence [61]. This toothpaste contains a more abrasive system for extrinsic stains removal compared to various bleaching toothpastes based on silica [62]. This advantage made toothpastes containing Blue Covarine a choice for post-bleaching maintenance [7, 43].

Regarding mouthrinses with bleaching products, divergent outcomes could be shown. A previous article perceived the same color change when compared to home bleaching [59]. Contrary, other reports showed that these mouthrinses did not demonstrate a significant bleaching impact [63]. Normally, HP at low-concentration, citrate and potassium or sodium pyrophosphate, sodium hexametaphosphate were the components of bleaching mouthrinses [32]. The bleaching mouth rinse could contain other components like tetrasodium pyrophosphate, tetrapotassium pyrophosphate, and zinc citrate. A previous report showed that the period of exposure of the dental surface to bleaching mouthrinses was a factor that affected the bleaching outcome obtained [64]. On the other hand, fluoride-based bleaching mouthrinse and conventional toothpaste might deliver a remineralizing potential. However, a dentist should supervise the higher concentration of fluoride, and a free-fluoride agent would be necessary. Nevertheless, while the evidence shows a reduction in bleaching outcome for OTC products, the present review demonstrated that the association between whitening toothpastes and mouthrinses could be a viable option for maintaining color, 1 year following bleaching approach [32].

For fluoridated bleaching agent, when administered following bleaching or during bleaching step, a loss microhardness in bleached enamel might be lessened [65,66]. Fluoride-based CP bleaching gel induces acquisition of fluoride on enamel surface [67]. This effect is less marked then the pure fluoride gel, it might be theorised that the fluoride inside bleaching gel precipitated calcium and phosphate. Thus, it was postulated that the enamel demineralization is lower for enamel bleached with a fluoride-based CP bleaching gel [68]. Fluoride based bleaching gels in the form of 10% CP might support the post-bleaching remineralization, thus, considered a choice for maintenance of bleached enamel [18].

Besides the aforementioned agents, fractional CO_2 laser and nanohydroxyapatite were suggested for post-bleaching maintenance by preventing stain absorption of bleached enamel [33]. Many types of lasers existed with various parameters, in order to coincide with dentin and enamel structures the absorption bands of some ions are within 9.0 to 11.0 μ. This criterion helped enamel structure hardening [69]. It was shown that treating the enamel bleached surface with a laser, reduced hypersensitivity and maintained bleaching for a long period [70]. Another enamel treatment could be achievable with nanohydroxyapatite and fluoride just following the bleaching procedure. This enhances the enamel remineralization that had been demineralized in post-bleaching process [71]. It could be explained that nanohydroxyapatite formed a protective layer on the dentinal tubule, explaining the positive influence following enamel bleaching [47, 72]. Consequently, CO_2 laser and nanohydroxyapatite were considered efficient in maintenance of bleached enamel.

As for arginine-based products, a post-bleaching relief could be possible by applying it on enamel surfaces. Arginine is a natural amino acid representing one of the saliva components. Pro-Argin toothpastes (8% Arginine) and mouthwashes (0.8% Arginine) are such examples for repairing enamel demineralization [73, 74]. In addition, it facilitates the diffusion of arginine into the prisms of bleached enamel, permit-

ting a reduction of hypersensitivity [75], and precipitated calcium and phosphate inside dentinal tubules. Finally, arginine could enhance the remineralizing effect of bleaching without affecting the bleaching efficiency and this is possible in a 1.5% arginine-containing toothpaste with some fluoride and calcium based [73, 76]. This made this amino acid a choice for maintenance.

Some limitations can be found in this study. For first instance, the heterogenicity found in the articles included in the review prevented to perform any meta-analysis, and in this sense, any solid conclusion could not be defined. The first recommendation for further studies is to consider the evaluation of more standardized procedures. More in-vitro and clinical studies exploring the characteristics of the enamel after repeated bleaching and maintenance procedures should be performed. It is important to mention that some maintenance was effective for reducing sensitivity only not color so it will be helpful for researcher to make studies on these agents.

Conclusions

In conclusion, tooth whitening maintenance could be achieved by using some agents. The association of these agents might be beneficial for maintaining the color of the enamel throughout 12 months following bleaching procedure.

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