Review

Effect of tooth bleaching in patients with fixed orthodontic appliances: A systematic review

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D – writing the article; E – critical revision of the article; F – final approval of the article

Dental and Medical Problems, ISSN 1644-387X (print), ISSN 2300-9020 (online) *Dent Med Probl*. 2025;62(2):343–350

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Funding sources
This study was funded by the National Council for Scientific and Technological Development (CNPq) (No. 160339/2021-9).

Conflict of interest
None declared

Acknowledgements
None declared

Received on July 13, 2023
Reviewed on July 27, 2023
Accepted on August 28, 2023

Published online on April 4, 2025

Abstract

Patients seeking a harmonious smile that combines satisfactory aesthetics and stable occlusion raise questions about the concomitant association of treatments. This systematic review aimed to answer the following question: "Does the application of hydrogen peroxide on teeth with fixed metallic orthodontic brackets interfere with the dental bleaching effect?". The PICOS (Population, Intervention, Comparison, Outcome, and Study design) strategy and the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines were adhered to during the review process. A comprehensive search strategy was implemented, encompassing the PubMed®, Web of Science, Scopus, Embase, and LILACS databases. The risk of bias was assessed using the Cochrane risk of bias (RoB) 2.0 tool. The initial search yielded 51 articles, which were then filtered to remove duplicates. The titles and abstracts of 26 studies were subsequently reviewed. Eleven articles were selected for full-text reading, and after applying the eligibility criteria, 3 studies were included for qualitative analysis. Two studies were classified as having a low risk of bias, while 1 study was classified as having some concerns. The bleaching was satisfactory with 8% and 10% hydrogen peroxide (HP) applied for 45 min daily over 10 days, even with fixed orthodontic brackets. However, a single study that employed the in-office technique (38% HP) demonstrated that fixed orthodontic appliances influenced external tooth bleaching. Tooth bleaching using the home bleaching technique yielded effective results when performed alongside orthodontic treatment.

Keywords: orthodontic brackets, index of orthodontic treatment need, tooth bleaching, tooth whitening

Cite as
Lizarelli GTC, Manente R, Souza-Gabriel A, Corona SAM. Effect of tooth bleaching in patients with fixed orthodontic appliances: A systematic review. *Dent Med Probl.* 2025;62(2):343–350. doi:10.17219/dmp/171606

DOI
10.17219/dmp/171606

Highlights

- The systematic review assessed the impact of hydrogen peroxide on dental bleaching for teeth with fixed metallic orthodontic brackets.
- Effective bleaching was achieved using 8–10% hydrogen peroxide for 45 min daily over 10 days, even with fixed orthodontic brackets.
- Tooth bleaching combined with orthodontic treatment improves both functional stability and smile aesthetics.

Introduction

Aesthetic procedures aimed at tooth whitening are commonly sought after by patients.[1–3] These procedures have been shown to have a significant psychosocial impact, affecting aesthetic self-perception.[4–8] Tooth bleaching is one of the most commonly performed procedures in the dental office, especially in cases of tooth discoloration, tetracycline stains and extrinsic stains combined with the patient's diet.[9–11] It is a conservative alternative for restoring aesthetics in vital and non-vital teeth.[12]

The mechanism of action of the bleaching gel involves diffusion[9,13,14] due to the characteristic permeability of dental tissues (enamel and dentin) associated with low molecular weight and the ability of hydrogen peroxide (HP) to generate free radicals.[15,16] Diffusion capacity is related to factors such as the patient's age, which is a determining factor for the deposition of secondary dentin throughout life, causing the thickness of this dentin to increase and, consequently, decreasing the efficiency and penetration of HP.[9,17] Moreover, the diffusion capacity is associated with the concentration of peroxide,[18,19] application time, amplitude of dentinal tubules,[20] and variation in dental structure.[21]

Tooth bleaching is a minimally invasive approach that provides excellent aesthetic results.[22,23] Its applications have expanded in the field of orthodontics. Orthodontic treatment can result in changes to tooth color, prompting many patients to seek alternatives for restoring their tooth color.[24] Tooth bleaching has been shown to enhance the dental substrate, thereby enabling aesthetic procedures to re-establish the shape and size of teeth. This includes closure of the diastema and re-anatomization of conoid teeth, which are not fully addressed by orthodontics.[25,26]

The most common method of clinically assessing tooth color is through visual shade matching. This approach is quick and simple to apply. However, the subjective nature of this method stemming from variations in the perception of colors by the observer, lighting conditions, translucency, and the optical properties of the material examined, may affect the results.[27,28] Another method of assessing tooth color is through the use of a spectrophotometer, which was invented in 1940 by Beckman et al.[29] This tool measures the reflection properties of an object and converts them into color coordinates and various tooth shade values.

The use of HP in tooth bleaching procedures results in a polydirectional whitening effect, encompassing areas covered by orthodontic brackets.[30] Additionally, it helps control plaque and reduce gingivitis or periodontal diseases during treatment. Furthermore, it enables patients to achieve whitened teeth prior to orthodontic finishing, thereby optimizing time management.[31] A survey conducted among US orthodontic specialists revealed that a high percentage of participants (88.8%) reported that their patients requested tooth bleaching.[32] Another study demonstrated that patients exhibited higher levels of satisfaction with orthodontic treatment when it was combined with bleaching.[33] Hydrogen peroxide assists in regulating oral biofilm, and the bleaching procedure on teeth with brackets potentially serves as a motivational factor, preventing treatment withdrawal and reducing the total treatment duration.[31]

Clinicians could potentially consider a combination of both treatments (bleaching and orthodontics) to establish a stable functional occlusion and harmonious dentofacial aesthetics. Therefore, based on the scientific literature on the characteristics and advantages of tooth bleaching and its association with orthodontic treatment, the purpose of this systematic review was to ascertain whether tooth bleaching gel can be effective on tooth surfaces and whether it can provide satisfactory aesthetic outcomes in the presence of orthodontic brackets.

Material and methods

Protocol

This systematic review was conducted according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines based on the PICOS (Population, Intervention, Comparison, Outcome, and Study design) strategy, as follows: population (P) – patients with fixed orthodontic brackets; intervention (I) – tooth bleaching; comparison (C) – individuals with and without brackets; outcome (O) – bleaching effect; study design (S) – in vivo research articles. The review aimed to answer the following question: "Does the application of hydrogen peroxide on teeth with fixed metallic orthodontic brackets interfere with the dental bleaching

effect?". The study was registered with PROSPERO (registration No. CRD42023408848).

Search strategy

The literature search was independently conducted by 2 researchers (GTCL and RM) for reports published until May 2023 in the Embase, PubMed®, Scopus, Web of Science, and LILACS databases. English terms from Medical Subject Headings (MeSH) and free keywords with Boolean operators (OR, AND) were used in the search. The search strategy was adapted to each database and is listed in Table 1.

Eligibility criteria

The present review included clinical studies that evaluated patients who underwent tooth bleaching with HP in varying concentrations and with different application protocols. Studies that did not meet the eligibility criteria, as well as systematic reviews, editorials, letters, case reports, and in vitro studies that aligned with the proposed research question were excluded from the analysis.

Selection process

The articles were evaluated independently by 2 reviewers (GTCL and RM) in 2 stages according to the eligibility criteria. In the first phase, the selection of studies was based on the analysis of titles and abstracts, and in the second phase, the full-text articles were examined. Any doubts and discrepancies were addressed through consensus meetings with the coordinator (SAMC). Initially, the authors conducted a search of relevant databases and excluded duplicate and irrelevant articles. The titles and abstracts were then reviewed, and those that did not address the review question were removed. The remaining studies were read in full, and those that did not match the subject under investigation were excluded. Finally, articles meeting all the selection criteria were included (Fig. 1).

Each study was assigned an ID based on the name of the first author and the year of publication. Extraction forms customized for the study were used to gather information on study methods, designs and settings, characteristics of the participants, and bleaching protocols.

Risk of bias in individual studies

The risk of bias was assessed by 2 reviewers using the Cochrane risk of bias (RoB) 2.0 tool. This tool contains several items, including allocation concealment, sequence generation, blinding of participants and outcome assessors, incomplete outcome data, and selective outcome reporting. The evaluation of each domain of the RoB tool was conducted in accordance with the guidelines outlined in the Cochrane Handbook for Systematic Reviews of Interventions, 5.1.0.[34] The assessments of low risk, high risk, or some concerns were made based on the presence or absence of information or uncertainty regarding the potential for bias.

Table 1. Search strategies for each database

Database	Strategy
PubMed®	(tooth bleaching [MeSH Terms]) OR (teeth whitening [MeSH Terms]) OR (teeth bleaching [MeSH Terms]) OR (carbamide [MeSH Terms]) OR (hydrogen peroxide [MeSH Terms]) OR (agents, teeth whitening [MeSH Terms]) OR (agents, tooth whitening [MeSH Terms]) OR (teeth whitening agents [MeSH Terms]) OR (agents, bleaching [MeSH Terms]) AND (brackets, orthodontic [MeSH Terms]) OR (bracket, orthodontic [MeSH Terms]) OR (orthodontic bracket [MeSH Terms]) OR (orthodontic brackets [MeSH Terms]) AND (index of orthodontic treatment need [MeSH Terms]) OR (index of orthodontic treatment needs [MeSH Terms]) OR (index for need of orthodontic treatment [MeSH Terms])
Embase	(tooth bleaching: ti,ab,kw OR teeth whitening: ti,ab,kw OR teeth bleaching: ti,ab,kw OR carbamide: ti,ab,kw OR hydrogen peroxide: ti,ab,kw OR agents, teeth whitening: ti,ab,kw OR agents, tooth whitening: ti,ab,kw OR teeth whitening agents: ti,ab,kw OR agents, bleaching AND brackets, orthodontic: ti,ab,kw OR bracket, orthodontic: ti,ab,kw OR orthodontic bracket: ti,ab,kw OR orthodontic brackets: ti,ab,kw AND index of orthodontic treatment need: ti,ab,kw OR (index of orthodontic treatment needs: ti,ab,kw OR index for need of orthodontic treatment))
LILACS	(mh: (tooth bleaching)) OR (mh: (teeth whitening)) OR (mh: (teeth bleaching)) OR (mh: (carbamide)) OR (mh: (hydrogen peroxide)) OR (mh: (agents, teeth whitening)) OR (mh: (agents, tooth whitening)) OR (mh: (teeth whitening agents)) OR (mh: (agents, bleaching)) AND (tw: (brackets, orthodontic)) OR (tw: (bracket, orthodontic)) OR (tw: (orthodontic bracket)) OR (tw: (orthodontic brackets)) AND (tw: (index of orthodontic treatment need)) OR (tw: (index of orthodontic treatment needs)) OR (tw: (index for need of orthodontic treatment))
Web of Science	topic: tooth bleaching OR teeth whitening OR teeth bleaching OR carbamide OR hydrogen peroxide OR agents, teeth whitening OR agents, tooth whitening OR teeth whitening agents OR agents, bleaching AND brackets, orthodontic OR bracket, orthodontic OR orthodontic bracket OR orthodontic brackets AND index of orthodontic treatment need OR index of orthodontic treatment needs OR index for need of orthodontic treatment
Scopus	(Title-ABS-KEY: tooth bleaching OR Title-ABS-KEY: teeth whitening OR Title-ABS-KEY: teeth bleaching OR Title-ABS-KEY: carbamide OR Title-ABS-KEY: hydrogen peroxide OR Title-ABS-KEY: agents, teeth whitening OR Title-ABS-KEY: agents, tooth whitening OR Title-ABS-KEY: teeth whitening agents OR Title-ABS-KEY: agents, bleaching AND Title-ABS-KEY: brackets, orthodontic OR Title-ABS-KEY: bracket, orthodontic OR Title-ABS-KEY: orthodontic bracket OR Title-ABS-KEY: orthodontic brackets AND Title-ABS-KEY: index of orthodontic treatment need OR Title-ABS-KEY: index of orthodontic treatment needs OR Title-ABS-KEY: index for need of orthodontic treatment)

MeSH – Medical Subject Headings; ti – searches for the presence of a word (keyword) in the title of an article; ab – searches for the presence of a word (keyword) in the abstract of an article; kw – searches for author-provided keywords; mh – MeSH terms; tw – Text Word (searches for specific words or phrases in the text of an article); ABS – abstract; KEY – keywords.

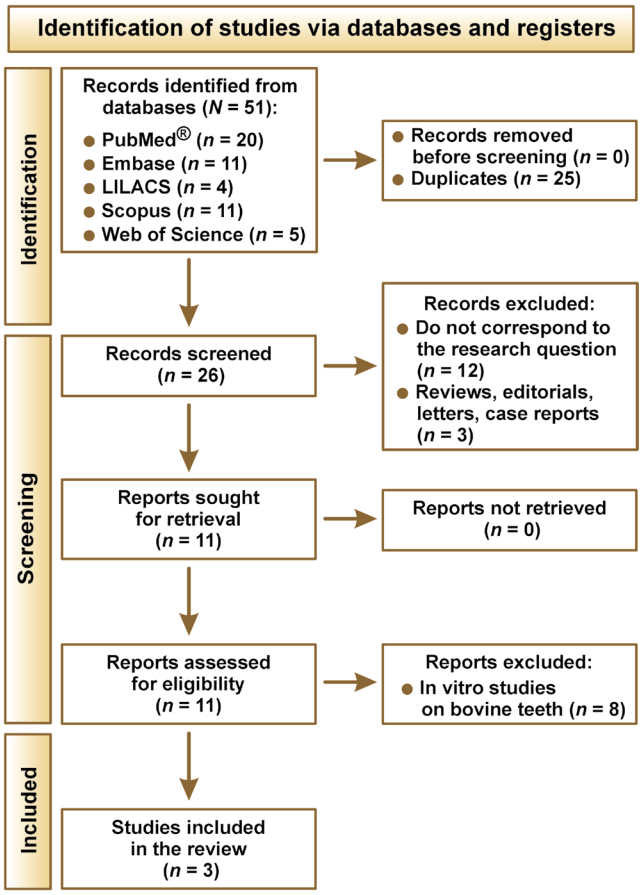

Fig. 1. Flowchart of the study

Results

Study selection

During the search, a total of 51 articles published until May 2023 were retrieved, and a pre-selection was performed after the removal of duplicates, yielding 26 articles. Eleven potentially eligible articles were selected for further evaluation after a review of their titles and abstracts. Subsequent to a thorough examination of the texts, 8 articles were excluded because they were not clinical studies, leaving 3 articles that were eligible for the present review.

Characteristics of the included articles

The following information was retrieved from each study: author/year of publication; number and age of the participants; groups; bleaching protocol; response variables; and results (Table 2). The 3 articles included in this review[35–37] were comparative clinical studies performed using parity between groups. Tooth staining was evaluated after tooth bleaching in patients undergoing orthodontic treatment with fixed brackets. The patients had a similar mean age.

For the purpose of color analysis, the studies used a digital system that utilized a spectrophotometer. The instrument enables the representation of colors in the International Commission on Illumination (CIE) L*a*b* format. Two studies used the VITA Easyshade® spectrophotometer (Vident, Brea, USA),[35,37] and 1 study used the SpectroShade Micro spectrophotometer (MHT, Zurich,

Table 2. Characteristics of studies included in the review

Study	Participants, *n*	Groups	Age [years]	Bleaching protocol	Response variables	Results
Jadad et al. 2011[35]	40	– bleaching with a fixed orthodontic bracket – bleaching without a fixed orthodontic bracket	18–40	8% HP – 45 min/day for 10 days	color: VITA Easyshade® spectrophotometer (Vident, Brea, USA)	Bleaching was effective in both groups.
Montenegro-Arana et al. 2016[37]	40	– bleaching with an orthodontic bracket (Trèswhite Ortho bleaching gel) – bleaching with an orthodontic bracket (Trèswhite Supreme bleaching gel)	18–40	– Trèswhite Ortho group: 8% HP – 45 min/day for 10 days – Trèswhite Supreme group: 10% HP – 45 min/day for 10 days	color: VITA Easyshade® spectrophotometer (Vident) sensitivity: 5-point scale, numerical rating scale ranging from 0 to 100, VAS	Both bleaching gels were effective.
Koumpia et al. 2022[36]	72	– debonded – undergoing retention – untreated	18–58	38% HP – according to the manufacturer's instructions	color: SpectroShade Micro reflectance spectrophotometer (MHT, Zurich, Switzerland), CIE L*a*b* system	Fixed orthodontic appliances influenced the bleaching efficacy. Tooth bleaching treatment had a greater effect when administered after orthodontic treatment.

HP – hydrogen peroxide; VAS – visual analog scale; CIE – International Commission on Illumination; L* – lightness; a* – red/green coordinate; b* – yellow/blue coordinate.

Switzerland) and the CIE L*a*b* format to calculate L* (lightness ranging from 0 (black) to 100 (white)), a* (red/green coordinate) and b* (yellow/blue coordinate) parameters.[36] Additionally, 1 study evaluated tooth sensitivity using a visual analog scale (VAS), a 5-point scale and a numerical rating scale ranging from 0 to 100.[37]

The number of patients included in the studies was 40,[35] 72[36] and 40.[37] In the 3 studies, the minimum age of the participants was 18 years, and the age range was 18–40 years,[35] 18–58 years,[36] and 18–40 years.[37] Notably, 1 study documented a higher proportion of female participants compared to male participants,[36] while the other 2 studies did not provide specific demographic data.

One of the 3 studies assessed tooth sensitivity.[37] The patients from 2 groups (Trèswhite Ortho and Trèswhite Supreme), both undergoing orthodontic treatment, were instructed to report the level of pain during the 10 bleaching sessions using VAS ranging from 0 to 4 (0 = none, 1 = mild, 2 = moderate, 3 = considerable, and 4 = severe) and a numeric rating scale ranging from 0 to 100. The highest values recorded for each session were divided into 2 categories: absolute risk of tooth sensitivity; and overall intensity of tooth sensitivity. The analysis revealed no statistically significant differences for both categories, with *p*-values of 0.53 and >0.05, respectively, for absolute risk of tooth sensitivity and overall intensity of tooth sensitivity.[37]

With regard to the bleaching protocol, the most frequently used agent was HP gel, and its concentration ranged from 8% to 38%. The gel application protocol varied among the studies: 8% HP was used for 45 min/day over 10 days[35]; 8% and 10% HP were used for 45 min/day over 10 days[37]; and 38% HP was used according to the manufacturer's instructions.[36]

A comparative analysis of the articles revealed similarities between the groups of teeth subjected to bleaching. Jadad et al.,[35] Koumpia et al.[36] and Montenegro-Arana et al.[37] included 6 maxillary anterior teeth in their studies. The outcomes of each study indicated that the bleaching protocols generally yielded positive results,[35,37] with the exception of 1 study,[36] the authors of which concluded that tooth bleaching treatment had a greater effect when administered after orthodontic treatment (Table 2).

Risk of bias

In accordance with the RoB 2.0 tool, the studies by Montenegro-Arana et al.[37] and Koumpia et al.[36] were rated "low risk", while the study by Jadad et al.[35] was rated "with some concerns" (Fig. 2).

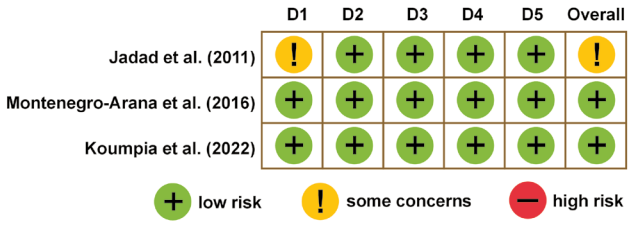

Fig. 2. Risk of bias in the randomized trials included in the review, assessed using the Cochrane risk of bias (RoB) 2.0 tool

D1 – bias arising from the randomization process; D2 – bias due to deviations from intended interventions; D3 – bias due to missing outcome data; D4 – bias in measurement of the outcome; D5 – bias in selection of the reported result.

Discussion

Bleaching is an aesthetic procedure that can be performed after the alignment of teeth and before the dental re-anatomization with composite resin.[38] When performed in conjunction with orthodontic therapy, it provides motivated patients with stable functional occlusion and harmonious aesthetics in a shorter period of time.[32,33,35,37] The existing evidence regarding the effect of bleaching on teeth that have undergone orthodontic treatment is inconclusive, thereby supporting the need for evidence-based information regarding such protocols. To the best of our knowledge, this is the first literature review to assess the outcomes of in vivo studies using concomitant tooth bleaching and orthodontic brackets.

Modifications in enamel color are associated with surface alterations due to irreversible penetration of resin tags following orthodontic bonding,[39] direct absorption of food colorants and products resulting from corrosion of the orthodontic appliance,[40] as well as decalcification and grooving during adhesive removal.[41] These disadvantages could potentially be avoided through tooth bleaching during orthodontic treatment. This hypothesis is based on the mechanism of action (diffusion) of bleaching gels under orthodontic brackets.[30] Hydrogen peroxide has a low molecular weight and the ability to generate free radicals, which diffuse easily into the lamellae, grooves, fissures, and depressions of the teeth.[15,16] Moreover, the variability in enamel pores, both in terms of size and location within or between hydroxyapatite prisms, has been demonstrated to affect treatment outcomes.[21] A previous systematic review evaluated the efficacy of home tooth bleaching combined with orthodontic aligners and showed positive outcomes with carbamide or HP.[42]

In this review, 2 studies demonstrated a favorable response to the home bleaching technique when combined with conventional orthodontic treatment.[35,37] Jadad et al. observed that the bleaching protocol of 8% HP (45 min/day for 10 days) simultaneous with orthodontic treatment provided satisfactory aesthetic results, similar to those obtained with post-orthodontic bleaching treatment.[35] Montenegro-Arana et al. used 2 bleaching agents (Trèswhite Ortho and Trèswhite Supreme) with a protocol involving the application of 8% and 10% HP (45 min/day) for 10 days, in 2 groups of patients with fixed orthodontic appliances.[37] The study yielded positive outcomes for tooth bleaching with both bleaching agents.[37]

However, the findings of Koumpia et al. differed from those of other studies.[36] The authors tested in-office bleaching with 38% HP, according to the manufacturer's instructions. They found that the orthodontic brackets had an influence on the bleaching effect. The bleaching process was associated with an increase in the L* value and a decrease in the a* and b* values in orthodontically-treated and untreated teeth. The color difference (ΔE), L* and b* parameters demonstrated significant differences between the groups not undergoing orthodontic treatment and those in the orthodontic retention phase. This outcome suggests that the bonding and debonding processes that took place during orthodontic treatment might have had a negative influence on the bleaching results.[36]

Debonding leads to morphological changes, such as the loss of enamel structure, which directly interferes with light reflection.[36] Additionally, debonding results in enamel discoloration due to the presence of residual adhesive within the prisms, as well as increased roughness and small fractures.[43–50] The discoloration of the adhesive affects the color of the enamel through physicochemical reactions and the absorption of food pigments.[45,51,52]

A plausible explanation for positive results observed with HP-based gels at low concentrations is that concentration and duration are key factors affecting the efficacy of bleaching treatments.[53] High concentrations demonstrate faster results than low concentrations. However, low concentrations can be equally effective if the treatment duration is extended. Additionally, the active agent in the bleaching gel only reaches the dentin region immediately below the enamel. This suggests that a low concentration and reduced penetrating power are necessary to achieve effective bleaching results.[54]

Because free radicals act in a polydirectional manner, they exert an effect under the brackets and resin adhesives, cementing orthodontic appliances.[55] The rheological properties of Opalescence Trèswhite Ortho gel are improved by the presence of polymers, which contributes to the control of oxygen release and the cohesion of the product on the tooth surface. In the context of orthodontic appliances, this effect maximizes the efficiency of the bleaching agent.[55]

The studies included in this review used either the VITA Easyshade® or the SpectroShade Micro spectrophotometer for color analysis. Both devices exhibited high accuracy[56,57] and reproducibility for tooth bleaching evaluation.[58] Montenegro-Arana et al. evaluated tooth color before and 30 days after the bleaching procedure using the VITA Easyshade® device.[37] The results were assigned values based on the VITA classical color scale. Similarly, Jadad et al.[35] used VITA Easyshade® and the same color allocation parameters as those used in the study by Montenegro-Arana et al.[37] Koumpia et al. utilized the SpectroShade Micro reflectance spectrophotometer, and the color standard was analyzed using the CIE L*a*b* system.[36]

The use of different methodologies and devices for measuring the color before and after bleaching, as well as the application of different protocols and concentrations of the bleaching gel, may have contributed to the divergence in the studies regarding home and in-office techniques.

Overall, this review has determined a change in tooth color to lighter shades, thereby confirming the efficacy of the bleaching gel in the presence of orthodontic brackets for the home bleaching technique. The limitations of this review are due to the low number of studies assessed. Additionally, one of the included studies did not incorporate a randomization process for the samples. Therefore, further randomized clinical studies on the combined treatment and with a longer follow-up are recommended to elucidate its effects on the tooth structure over time.

Conclusions

In light of the limitations inherent to a systematic review and based on the results of the selected studies, it can be concluded that the concomitant application of orthodontic brackets and tooth bleaching offers favorable outcomes for patients in terms of aesthetics and function. The procedure of tooth bleaching was effective when using protocols based on 8% and 10% HP for 45 min/day over a period of 10 days.

Trial registration

The study was registered with PROSPERO (registration No. CRD42023408848).

Ethics approval and consent to participate

Not applicable.

Data availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Consent for publication

Not applicable.

Use of AI and AI-assisted technologies

Not applicable.

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