

# Effect of Over-the-counter Whitening Toothpaste and Mouthwash in Orthodontics: A Literature Review

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## ABSTRACT

**Aim:** To summarize and analyze all the available literature on the use of over-the-counter toothpaste and mouthwashes with whitening agents and their possible effects on orthodontic treatment.

**Background:** Tooth color change frequently occurs during orthodontic treatment and represents a self-perceived need. According to the patient's perspective, there is a preference for the use of toothpaste and mouthwashes with some whitening effect.

**Materials and methods:** An electronic bibliographic search in English was carried out until June 2022, in PubMed, Scopus, and Web of Science databases. Randomized or nonrandomized clinical trials and experimental laboratory studies were included.

**Review results:** A total of 57 papers were obtained from an electronic search and 11 studies were included in the review. Outcomes such as strength force elastomeric, color stability, frictional resistance, ion release, shear bond strength (SBS), and adhesive remnant index (ARI) were evaluated.

**Conclusion:** Toothpaste and mouthwashes with whitening action did not have a favorable effect on most of the outcomes evaluated. In some cases regular toothpaste showed a better effect and in other cases, there were no differences with the control group. Only in the outcome release of ions from wires to whitening effect in teeth with or without attached brackets, they have a better performance.

**Clinical significance:** Due to the unfavorable effects of over-the-counter whitening toothpaste and mouthwashes on orthodontic materials and appliances, their use should be justified during treatment.

**Keywords:** Mouthwashes, Orthodontics, Review, Toothpaste.

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## BACKGROUND

It has been observed that tooth color change may occur during orthodontic treatment due to irregular accumulation of chromogens and bacterial plaque, resulting in a self-perceived need for orthodontic patients and may affect the final esthetic result.<sup>1</sup> Consequently, the orthodontist must address various strategies to maintain oral hygiene and will probably recommend the use of oral hygiene products, which should be aimed at promoting the remineralization and removal of dental plaque, but also at preserving the color of the teeth.<sup>2</sup>

Tooth whitening during orthodontic treatment is not part of most of the treatments suggested by orthodontists, because the presence of a bracket on the enamel can act as a physical barrier that prevents the proper penetration of peroxide, ultimately, it can compromise the whitening effect desired by the patient.<sup>1,3</sup> On the contrary, according to the patient's perspective, it has been shown that there is a preference for the use of pastes and rinses with some whitening effect, even for other whitening methods in the office.<sup>1,4</sup>

Since these toothpaste and mouthwashes with whitening agents are over-the-counter oral hygiene products in most countries, patients end up using them even without professional advice.<sup>5-7</sup> Products with over-the-counter whitening agents can be obtained directly by consumers in pharmacies, supermarkets, and web stores, becoming inexpensive alternatives with a certain effect.<sup>8-11</sup> Therefore, it is necessary to know if these whitening agents contained in commercially available products have any scientific evidence that supports their use as well as their effects in orthodontic treatment.

The objective of this research is to summarize and analyze all the available literature on the use of over-the-counter toothpaste

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and mouthwashes with whitening agents and their possible effects in orthodontic treatment.

## MATERIALS AND METHODS

The research question was based on the patient, intervention, comparison, outcome (PICO) model, in the context of the situation represented by color changes in teeth during orthodontic treatment (problem) and how the use of over-the-counter toothpastes or mouthwashes with whitening agents (intervention) can affect materials, appliances, or teeth structure (outcome), compared to regular toothpastes and mouthwashes or a control group (comparator).

An electronic bibliographic search was carried out in the following databases—PubMed, Scopus, and Web of Science. Only literature published in English was considered and the search for records was performed using search expressions for each database, which are presented in Table 1. The paper screening, selection for eligibility, and qualitative data analysis were carried out by two independent peer reviewers (SC, MO) to prevent bias. In case of any disagreement, the decision was made by a third reviewer (VS). In the first phase, the title and abstract of the papers were evaluated; while in the second phase, the full text was collected for all identified papers in order to assess the eligibility of the qualitative analysis. Randomized or nonrandomized clinical trials and experimental laboratory studies were included in this review. Letters to the editor, case reports, case series, observational studies, literature reviews, systematic reviews, study protocols, newsletters, advertisements, and editorials were excluded. Likewise, the bibliographic recovery period included publications until 11<sup>th</sup> June 2022.

## REVIEW RESULTS

A total of 57 papers were retrieved, of which the following were obtained—13 records for PubMed, 36 for Scopus, and eight for Web of Science. Zotero referencing software was used to remove duplicates, keeping a total of 48 records. The entered records were screened and after reviewing the full-text papers, the proposed exclusion criteria were applied to obtain the 11 studies on which the present review was based (Fig. 1).

### Description of Studies

There are currently a significant number of over-the-counter whitening toothpaste and mouthwashes, few with available scientific evidence, and most without any report of their clinical effectiveness in the context of orthodontic treatment. Table 2 describes the characteristics of the studies included and summarizes the effect of toothpaste and mouthwashes with whitening agents on materials, appliances, and enamel.<sup>8,11–20</sup>

### Type of Studies

Of the 11 included studies, nine evaluated at least one toothpaste with a whitening agent,<sup>8,11–14,16,18–20</sup> and two used mouthwashes.<sup>15,17</sup>

Similarly, nine included a laboratory experimental phase,<sup>8,11–18</sup> while only two studies also included a clinical phase to assess outcomes.<sup>19,20</sup>

### Materials, Appliances, and Structures Tested

Ligatures and chains elastomeric,<sup>12,13,15,16,19</sup> stainless steel brackets,<sup>8,14,18,20</sup> polycrystalline ceramic brackets,<sup>11</sup> nickel titanium and stainless steel wires,<sup>14,17</sup> and human and bovine tooth enamel.<sup>8,18,20</sup>

### Outcomes Evaluated

Studies included in the review assessed outcomes such as strength force elastomeric,<sup>13,15,19</sup> color stability,<sup>8,11,12,16,18,19</sup> surface characteristics,<sup>11,19</sup> frictional resistance,<sup>14</sup> ion release,<sup>17</sup> shear bond strength (SBS),<sup>8,18,20</sup> remaining adhesive,<sup>18,20</sup> and enamel morphology.<sup>8</sup>

## DISCUSSION

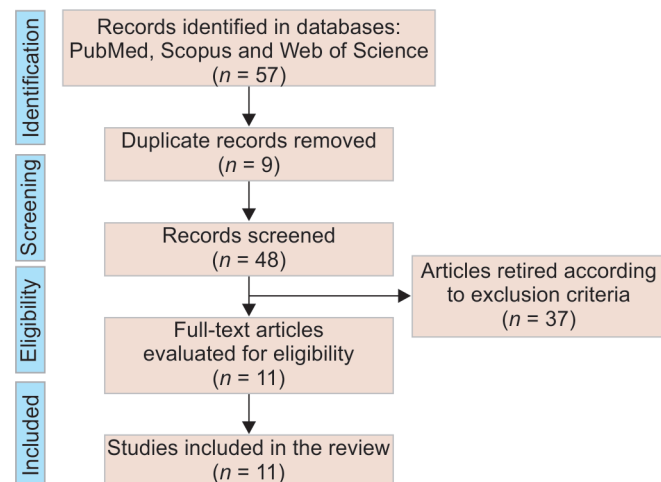
There are formulations specifically designed to have a whitening action, which includes chemicals such as peroxides, citrates, and pyrophosphates, as well as certain enzymes and surfactants.<sup>21,22</sup> The findings found in the studies showed that the toothpastes and mouthwashes with whitening action did not have a favorable effect on the outcomes evaluated and in some cases did not show differences with the control group or with regular toothpastes and mouthwashes.

### Strength in Elastomeric Materials

Regarding the degradation pattern of the elastomeric strength over time, it can be explained by the stretching mechanism that produces stress in the molecular polymer within the chain, sliding the polymer molecules, appearing broken primary bonds, and permanent deformation. Fluid absorption, which causes a plasticizing effect, is a second event that can explain this strength degradation.<sup>23</sup> In this sense, the whitening toothpaste produced a loss of force in the elastomeric chains and ligatures in a short period of time, depending on the manufacturer and the intrinsic characteristics of the type of material.<sup>13,19</sup> In a similar way mouthwashes with whitening action, although the latter in a longer period of time.<sup>15</sup>

**Table 1:** Database search strategies

Database	Search expression
PubMed	(((toothpaste[Title/Abstract]) OR (dentifrice[Title/Abstract]) OR ("dental cream"[Title/Abstract]) OR (((mouthwash*[Title/Abstract]) OR ("oral rinse"[Title/Abstract]) OR (mouthrinse[Title/Abstract]) OR ("mouth rinse"[Title/Abstract]) OR ("oral rinsing"[Title/Abstract])) AND (((whitening[Title/Abstract]) OR (bleaching[Title/Abstract]) OR (whiteners[Title/Abstract])) AND (orthod*[Title/Abstract]))
Scopus	((toothpaste OR mouthwash) AND (whitening OR bleaching)) AND (TITLE-ABS-KEY ( orthodontics))
Web of Science	(((TS=(toothpaste) OR TS=(dentifrice) OR TS=(mouthwash) OR TS=("oral rinse")) AND TS=((TS=(whiten*) OR TS=(bleach*)) AND TS=(TS=(orthod*))



**Fig. 1:** Preferred reporting items for systematic reviews and meta-analyses (PRISMA) flowchart showing a systematic sequence for included studies

**Table 2:** Characteristics of included studies

Author (year)	Methods	Sample, specimens	Intervention	Evaluation period	Results and inference
Oliveira et al. (2015) <sup>12</sup>	Experimental <i>in vitro</i>	80 elastomeric ligatures (3M Unitek, Monrovia, United States of America, and Morelli, Sorocaba, Brazil)	Toothpastes: GT1: Close Up Regular® GT2: Close Up White Now® GC: Distilled water	Baseline, 7, 14, 21, and 28 days (repeated measures approach)	The toothpaste with whitening action compared to the regular toothpaste, caused a greater color variation in both types of ligature, decreasing the yellow color but increasing the blue color ( $p < 0.05$ )
Behnaz et al. (2017) <sup>13</sup>	Experimental <i>in vitro</i>	300 pieces of elastomeric chains (3M Unitek, Monrovia, United States of America)	Toothpastes: GT1: Crest Anticavity® GT2: Crest 3D Whitening® GT3: Sensodyne® GT4: Sensodyne Gentle Whitening® GC: Distilled Water	Baseline, 1, 7, 14, 21, and 28 days	Both whitening dentifrices produced adverse effects in loss of strength on the elastomeric chains. Sensodyne Gentle Whitening® caused the most loss compared to a control group and regular toothpaste ( $p < 0.05$ )
Hosseinzadeh et al. (2017) <sup>14</sup>	Experimental <i>in vitro</i>	90 metal brackets with stainless steel wires (Dentsply GAC, New York, United States of America)	Toothpastes: GT1: Colgate Total Advanced Whitening® GT2: Colgate Total Pro Gum Health® GT3: Colgate Anticavity® GT4: OrthoKin® GT5: Sunstar GUM Ortho® GC: No toothpaste	For 4.5 minutes using toothpaste at a frequency of 150 cycles/minute, equivalent to 1 month of tooth brushing, 3 times a day	Colgate Total Advanced Whitening® produced higher values of friction resistance compared to regular toothpastes and control group; however, differences were not significant ( $p = 0.220$ )
Behnaz et al. (2018) <sup>15</sup>	Experimental <i>in vitro</i>	160 pieces of closed elastomeric chains (American Orthodontics, Wisconsin, United States of America)	Mouthwashes: GC: Artificial saliva GT1: Listerine Total Care Zero® GT2: Listerine Healthy White®	Baseline, 1, 7, 14, 21, and 28 days	The force of elastomeric chains was similar in all groups until 4th week, when force decay was higher in group Listerine Healthy White® compared to other groups ( $p < 0.001$ )
Hussein and Mohammed (2018) <sup>16</sup>	Experimental <i>in vitro</i>	60 elastomeric ligatures Ormco Clear (Scafati, Italy)	Toothpastes: GC: No Brushing GT1: Kin Progressive White® GT2: Lacalut White® GT3: Silca Brilliant White® GT4: Opalescence White® GT5: Kin Regular®	Baseline and 4 weeks later	Kin Regular® toothpaste reduce color variation in ligatures compared to whitening toothpastes ( $p = 0.00$ ). Within these, Opalescence White® with Blue Covarine pigment had a better performance
Mihashemi et al. (2018) <sup>17</sup>	Experimental <i>in vitro</i>	120 orthodontic wires: 60 nickel-titanium and 60 stainless steel wires (American Orthodontics, Sheboygan United States of America)	Mouthwashes: GT1: Oral B® GT2: Oral B 3D White Luxe® GT3: Listerine® GT4: Listerine Advance White® GC: Distilled water	For 1, 6, 24, and 168 hours (1 week)	Oral B 3D White Luxe® and Listerine Advance White® produced release of ions from wires. However, it was less than release in regular mouthwash ( $p = 0.00$ ) and not different to control group ( $p > 0.05$ )

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Author (year)	Methods	Sample, specimens	Intervention	Evaluation period	Results and inference
Torres et al. (2020) <sup>18</sup>	Experimental <i>in vitro</i>	80 bovine incisor with metal brackets (3M Unitek, Monrovia, United States of America)	Toothpastes: GT1: Colgate Total 12® GT2: Curaprox Black Is White® GT3: Luminous White Advanced® GC: Distilled water	50,000 simulated brushing cycles were performed, corresponding to 12 months	Luminous White Advanced® presented lower SBS and higher whitening effect, compared to regular toothpaste and control group ( $p < 0.05$ ). It also had a high ARI
Hohlen et al. (2021) <sup>8</sup>	Experimental <i>in vitro</i>	75 human premolars for cementation of incisor metal brackets (3M Unitek, Monrovia, United States of America)	Toothpaste: GT1: Crest 3D White Luxe Professional Effects Whitestrips® GT2: Crest® 3D White Brilliance 2-Step Toothpaste® GC: Unbleached	Baseline, 24 hours, and 7 days	Whitening toothpaste produced no differences in SBS of brackets ( $p = 0.650$ ) and tooth color change ( $p > 0.05$ ) compared to the control group. There were also no morphological differences in enamel
Flores et al. (2022) <sup>19</sup>	Experimental clinical and <i>in vitro</i>	Silicone and polyurethane elastomeric ligatures used in brackets of 40 patients (ROM, Colorado, United States of America and Dentsply GAC, New York, United States of America)	Toothpastes: GT1: Colgate Luminous White® GT2: Colgate Maximum Cavity Protection® GC: No toothpaste	Baseline and 30 days of use for each of the toothpastes with a 30-day washout	Whitening toothpaste did not influence color stability or elastic properties, compared to control group ( $p > 0.05$ ). However, induced more irregular surfaces and imperfections
Pavan et al. (2022) <sup>11</sup>	Experimental <i>in vitro</i>	50 polycrystalline ceramic orthodontic brackets (In-Ovation C Dentsply GAC, New York, United States of America)	Toothpastes: GC: No brushing GT1: Brushing With distilled water GT2: Brushing with Colgate Total 12 Clean Mint® GT3: Brushing with Colgate Optic White® GT4: Brushing with Close-Up White Attraction®	Baseline and after 1, 7, 14, and 21 days of staining and brushing cycles	Colgate Optic White® exhibited a surface with higher porosity on ceramic brackets. Whitening toothpastes not prevent the greater discoloration of brackets compared to regular toothpaste ( $p < 0.05$ )
Sfondrini et al. (2022) <sup>20</sup>	Experimental clinical and <i>in vitro</i>	220 bovine incisor for cementation of metal brackets (3M Unitek, Monrovia, United States of America)	<i>In vitro</i> : 21 Toothpastes with different Dentin Abrasivity Index (RDA), including whitening toothpastes Clinical trial: GT1: Advance White Paste Baking Soda and Peroxide® GT2: Colgate 2 in 1 Tartar Control/Icy Blast Whitening®	<i>In vitro</i> : Pretreatment with toothpastes for 1 minute; clinical trial: 12 months	Whitening toothpastes showed a higher RDA and lower SBS ( $p < 0.05$ ), compared to the other groups. There was a positive correlation between RDA and ARI ( $r = 0.24$ ). Clinically, there was a lower survival rate of bracket adhesion using pastes with higher RDA ( $p < 0.03$ )

### Color Stability and Surface Characteristics

Regarding the color change of the elastomeric materials, the whitening dentifrices caused significant color changes but toward a blue color.<sup>12,19</sup> In this sense, it would be necessary to check if the patient who invests in a whitening toothpaste is willing or not to obtain a blue color tendency compared to the yellow color. The latter would be even more interesting, considering that according to the reported results, the color changes in elastomeric ligatures would be less in dentifrices

without whitening agents.<sup>16</sup> This could be related to the differences in glass transition temperature during the manufacture of the ligatures tested in the studies and it is precisely at this point that color variations may be related to the surface characteristics of the materials tested,<sup>24</sup> variations in the porosity and roughness that could be accentuated by bleaching agents causing greater retention of pigments.<sup>19,25</sup>

Regarding orthodontic ceramic brackets, a greater capacity of coffee to stain both monocrystalline and polycrystalline ceramic

brackets has been verified, which together with the high abrasive index of the components of whitening toothpastes,<sup>20</sup> has resulted in a limited action to prevent variations of color in ceramic brackets due to a significant difference to cause greater surface porosity, which facilitates the incorporation of pigments.<sup>11,24</sup>

Regarding the color change in dental enamel, toothpastes with hydrogen peroxide in low concentrations were used, showing opposite results. One study opted to use human enamel and evaluate the whitening effect before bracket bonding, using saliva as a control; eight while the other study used bovine enamel attached to brackets with water as a control, reporting a better whitening effect.<sup>18</sup> It could be argued that evaluating the color change in enamel with brackets would be better, but difficulties using the spectrophotometer and the inevitable involvement of saliva should be considered.

### Frictional Resistance

Although it has been shown in some studies that the modification of the surface of the materials may be related to frictional forces,<sup>26</sup> the included study was able to establish that a whitening toothpaste with high abrasiveness causes increased values of frictional force but without significance.<sup>14</sup> The unevaluated dynamic frictional force together with the viscosity and pH of the solutions, the immersion, and brushing cycles, could have decreased the frictional forces generated by the known abrasive effect of toothpastes on the surfaces of stainless steel brackets and wires.<sup>20,26</sup>

### Ion Release

The increase in Ni and Cr ions has been reported in saliva, with high initial values but which decrease over time and depending on various factors such as the pH of the solution or mouthwash.<sup>27</sup> In this sense, the highest values reported by the included study were reported for Listerine with an acidic pH ( $4 \pm 0.5$ ) compared to other mouthwashes with a different pH ( $7 \pm 0.5$ ). However, the values also fluctuated over time, with nickel–titanium wires being more susceptible to ion release compared to stainless steel wires.<sup>17</sup>

### Shear Bond Strength

Reduced bond strength in bleached teeth has been related to changes in enamel minerals and proteins.<sup>28</sup> In this sense, according to the review, the pastes with the greatest potential to produce variations in the enamel surface, presented less resistance to shearing forces in the union of stainless steel brackets.<sup>18</sup> Reinforcing the idea that the strength of adhesion to the teeth is highly influenced by its degree of demineralization, a negative correlation between abrasiveness and shear strength values has also been observed.<sup>20</sup> However, it has also been stated that most toothpastes cause little change in enamel, depending more on the content of detergents and abrasive particles instead of oxidizing agents. A single study found that whitening pastes did not have a significant decrease in resistance to shear forces on brackets compared to the control group, which consisted of saliva.<sup>8</sup> It is possible that the artificial saliva used as a storage medium contains components capable of protecting the enamel surface, reducing microporosities.<sup>28</sup>

### Remaining Adhesive and Enamel Morphology

Adhesive remnant analysis is performed to reinforce the evaluation of resistance to shear forces, using the adhesive remnant index (ARI).<sup>29</sup> In two included studies, whitening toothpastes with high abrasiveness frequently had ARI values of

2 and 3,<sup>18,20</sup> that is, at least half of the adhesive cement remains in the bovine enamel after removal. An important factor to consider is the use of phosphoric acid in conventional adhesion systems, which increases the adhesive remnant in the enamel,<sup>29</sup> as occurred in the two included studies. Another important factor that intervenes is the morphology of the base of the brackets and the structural characteristics of the enamel.<sup>28,29</sup> In this regard, a third study found no differences in the morphology of the enamel for whitening toothpaste,<sup>8</sup> where the same brackets from the two previous studies were used, but evaluating human enamel with a control medium such as saliva that may have some effect on enamel remineralization.<sup>28</sup>

### Limitations

This review has methodological limitations as it is a qualitative summary and analysis, where almost all the included studies evaluated samples or specimens only under *in vitro* conditions. Therefore, since these are laboratory findings, they should not be interpreted as clinical recommendations because there are many environmental factors that could influence the performance of these toothpaste or mouthwashes and that cannot be replicated *in vitro* studies. However, the characteristics described in this review can be used to indicate whether certain oral hygiene products with some whitening effect appear viable enough to be tested in clinical studies.

### CONCLUSION

Luminous White Advanced® presented a high whitening effect on bovine teeth with brackets, lower SBS, and high ARI values. Colgate Luminous White® does not affect color stability or elastic properties of elastomeric ligatures, producing more irregular surfaces; while Colgate Total Advanced Whitening® produced values not significant of friction resistance between brackets and wires. Colgate Optic White® and Close-Up White Attraction® not prevent discoloration of polycrystalline ceramic brackets and produce a surface with increased porosity.

Advance White Paste Baking Soda and Peroxide® and Colgate 2 in 1 Tartar Control/Icy Blast Whitening® presented a lower survival rate of bracket adhesion, clinically. *In vitro*, whitening toothpastes had higher relative dentin abrasivity (RDA) and lower SBS.

Crest 3D White Brilliance 2-Step® toothpaste not produce differences in SBS, human tooth color without brackets, and enamel surface. Sensodyne Gentle Whitening® and Crest 3D Whitening® caused loss of force on elastomeric chains.

Oral B 3D White Luxe® and Listerine Advance White® produced release not significant of ions from wires, while Listerine Healthy White® produced a decreased force of elastomeric chains.

Close Up White Now® did not significantly prevent color variation in elastomeric ligatures, decreasing the yellow color, and increasing the blue color.

Kin Progressive White® and Lacalut White® did not significantly prevent color variation in elastomeric ligatures while Opalescence White® with Blue Covarine pigment had a better result.

### Clinical Significance

Over-the-counter dentifrices and mouthwashes with whitening agents have a whitening effect on teeth and produce less ion release under *in vitro* conditions; however, considering the available evidence regarding unfavorable effects on the rest of the outcomes evaluated, its use during orthodontic treatment should be justified.

In addition, this review allowed us to show that there is little clinical evidence on the use of these products in orthodontic treatment, compared to the wide diversity of commercially available options.

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