

# Can Enhanced Peroxides Decrease the Side Effects of Tooth Bleaching? A Systematic Review of the Literature

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## ABSTRACT

Adverse effects of tooth bleaching on dental structures remain a topic of discussion in the literature, and the search for protocols that reduce such reported adverse effects is ongoing. The goal of this systematic literature review was to determine whether the use of tooth bleaching gels with added minerals, such as fluoride, calcium, hydroxyapatite, potassium nitrate, amorphous calcium phosphate, and casein phosphopeptide-amorphous calcium phosphate, reduced the occurrence of the main adverse effects of tooth bleaching. The electronic database search identified 16 studies that evaluated the effects of bleaching gels with added minerals on enamel hardness and/or roughness, mineral loss, post-treatment sensitivity, morphological changes, and/or cohesive enamel strength. The findings of this review suggest that the addition of minerals to bleaching gels can contribute to the reduction of most adverse effects, mainly sensitivity, without affecting treatment efficiency.

**Keywords:** Tooth bleaching, Mineral, Peroxide.

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## INTRODUCTION

Patients' demand for a smile with white teeth have grown exponentially in recent decades.<sup>1</sup> Tooth bleaching has gained popularity among currently performed cosmetic procedures due to its proven effectiveness<sup>2</sup> and conservative nature compared with traditional restorative treatments using ceramics and composites.<sup>3</sup> However, adverse effects of tooth bleaching on dental structures remain a topic of discussion in the literature. Several studies have demonstrated changes in hardness, roughness, and dental morphology, generated

mainly by mineral loss during the bleaching procedure.<sup>4-7</sup> Tooth sensitivity and gum irritation are other common effects of tooth bleaching. Thus, the search for protocols that reduces such adverse effects is ongoing.<sup>8</sup>

A recently investigated alternative to reduce the adverse effects of tooth bleaching is the use of bleaching agents with added minerals, such as fluoride (F), calcium (Ca), hydroxyapatite (HA), potassium nitrate, amorphous calcium phosphate (ACP), and casein phosphopeptide-amorphous calcium phosphate (CPP-ACP).<sup>9-12</sup> The use of gels containing minerals that were lost by tooth structure during contact with the product would justify such use and can also minimize the occurrence of tooth sensitivity.<sup>7,13</sup> Reduced tooth sensitivity constitutes a great advantage to the patient and provides more comfort during the bleaching procedure.<sup>14</sup> Although, several studies have examined the use of bleaching gels containing minerals, a systematic analysis of their results is needed to provide scientific evidence for the effectiveness of the mineral content in reducing adverse effects. The objective of the current systematic review was thus to determine whether the use of dental bleaching gels with added minerals reduced the occurrence of the main adverse effects of tooth bleaching.

## MATERIALS AND METHODS

A systematic review of literature contained in the PubMed, Scielo, ScienceDirect, EBSCO, Cochrane, and Scopus databases was conducted using the following keywords: tooth, teeth, dental whitening, bleaching, calcium, phosphate, fluoride, fluorine, sodium fluoride, sodium fluorine, ACP, amorphous calcium phosphate, CPP-ACP, calcium phosphopeptide-amorphous calcium phosphate, hardness, roughness, mineral loss, morphological change, change morphology, sensitivity, elastic modulus, and scanning electron microscopy (SEM) (Table 1). Original and complete articles published in English between 2001 and 2012 were selected for inclusion in the review. We included case reports, *in vitro* studies, and clinical trials that reported information about adverse effects to the tooth structure (hardness, roughness, surface morphology, and mineral content of enamel; frequency/intensity of tooth sensitivity and mineral loss) resulting from the use of bleaching gels containing minerals.

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**Table 1:** Literature search strategy

1. (tooth or teeth or dental) and (whitening or bleaching)
2. (strategy #1) and ('calcium' or 'phosphate' or 'fluoride' or 'fluorine' or 'sodium fluoride' or 'sodium fluorine' or 'ACP' or 'amorphous calcium phosphate' or 'phosphopeptide calcium-amorphous calcium phosphate' or 'CPP-ACP')
3. (strategy #1) and (strategy #2) and ('hardness' or 'roughness' or 'mineral loss' or 'morphological change' or 'morphology change' or 'sensitivity' or 'elastic modulus' or 'SEM' or 'scanning electron microscopy')

Studies that did not describe sample storage conditions, the type of dental substrate used, the types and concentrations of bleaching agents tested, and/or the type and concentration of the mineral added to the bleaching gel were excluded from the analysis. Two independent examiners evaluated the articles and determined by consensus which articles were included in the analysis.

## RESULTS

Flow Chart shows the number of studies selected from each database. Sixteen articles were included in the systematic review; their contents are summarized in Table 2. The studies included reports of 62 bleaching treatments, 36 of which were conducted with whitening gel containing added minerals. Evaluation periods varied among studies, including various combinations of before, during, immediately after, and one or more intervals after bleaching. Samples that were used in *in vitro* studies were commonly preserved in remineralizing solution, human saliva, or artificial saliva. The bleaching gels and minerals added were categorized according to the active substrate and its concentration [e.g. 3.25% hydrogen peroxide (HP) + 5% CPP-ACP]. Only one study evaluated tensile strength in human enamel specimens.

Bleaching treatments performed with gels containing minerals were compared with a reference sample of those

performed with no added mineral (control group) in 12 studies. Substrate analysis was performed immediately after 36 bleaching treatments and after a post-treatment interval in 14 cases. Six articles reported the evaluation of enamel hardness, which increased, decreased, and remained unchanged following the use of bleaching gels with added minerals in two cases each.

All articles in the sample reported on *in vitro* studies. Bovine and human teeth were used. Hydrogen and carbamide peroxides were tested. The studies used bleaching gels containing a wide variety of minerals and bleaching protocols (4-8 hours/day for 7-14 days). All samples were stored in artificial saliva.

Two *in vitro* studies evaluated roughness of bovine<sup>6</sup> or human<sup>15</sup> enamel, the compositions of which are similar.<sup>16-18</sup> The first study evaluated the clinical and home application of HP and carbamide gels containing CPP-ACP, which increased enamel roughness. The second study evaluated the application of HP gel containing ACP, which did not change roughness values.

Cavalli et al<sup>19,20</sup> evaluated mineral loss in human enamel in two *in vitro* studies with similar protocols. Samples were stored in a remineralizing solution that simulated saliva (1.5 mM CaCl<sub>2</sub>, 0.9 mM Na<sub>2</sub>PO<sub>4</sub>, 0.15 mM KCl; pH = 7). Carbamide peroxide gels with hydrochloride calcium or sodium fluoride were compared with a gel containing no additional mineral (control). The bleaching protocol was 6 hours/day for 14 days. Reduced mineral loss was observed after treatment in both studies.

Seven studies,<sup>7,9,12-14,45,46</sup> including case reports and clinical trials, evaluated postoperative sensitivity in human enamel, which decreased in four studies and did not increase in three studies. The bleaching agents used contained 10 to 16% carbamide peroxide or 35% HP, with additional mineral

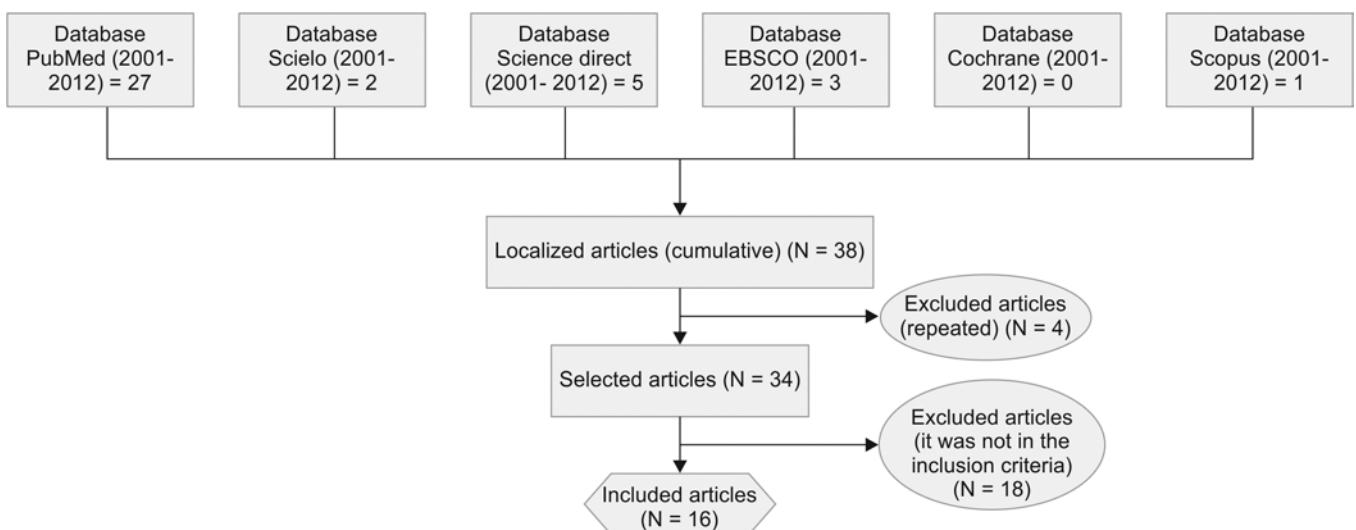
**Flow Chart 1:** Study selection

Table 2: Summary of studies included in the analysis

Publication	Substrate, study design	Gel + mineral	Exposure time	Storage medium	Adverse effects evaluated	Evaluation timepoints	Effect of mineral addition
Vasconcelos et al 2012	BE, <i>in vitro</i>	<ol style="list-style-type: none"> <li>3.25% HP + 5% CPP-ACP</li> <li>2.5% HP + 6.6% CPP-ACP</li> <li>5% HP + 3.3% CPP-ACP</li> <li>7.5% HP</li> <li>8% CP + 5% CPP-ACP</li> <li>5.3% CP + 6.6% CPP-ACP</li> <li>10.6% CP + 3.3% CPP-ACP</li> <li>16% CP</li> <li>10% CPP-ACP</li> </ol>	CP: 4 h/d, 14 d HP: 60 min/d, 14 d	Artificial saliva	Hardness, roughness, morphological changes	Immediately after bleaching	Increased hardness and roughness, accumulation of granules suggestive of minerals
Borges et al 2011	HE, case report	11% CP + 5% CPP-ACP + 0.1% sodium fluoride + 1.5% potassium nitrate	8 h/d, 21 d	-	Sensitivity	Immediately after bleaching	No reported sensitivity
Borges et al 2011	BE, <i>in vitro</i>	<ol style="list-style-type: none"> <li>5% CP + 5% CPP-ACP + 0.1% sodium fluoride + 1.5% potassium nitrate</li> <li>8% CP + 5% CPP-ACP + 0.1% sodium fluoride + 1.5% potassium nitrate</li> <li>10% CP + 0.1% sodium fluoride + 1.5% potassium nitrate</li> <li>16% CP + 0.1% sodium fluoride + 1.5% potassium nitrate</li> </ol>	8 h/d, 14 d	Artificial saliva	Hardness	Immediately after bleaching	Gels with CPP-ACP increased hardness; gels without CPP-ACP did not change initial hardness
Abreu et al 2011	HE, <i>in vitro</i>	<ol style="list-style-type: none"> <li>9.5% HP + % nif ACP + % nif potassium nitrate + % nif fluoride</li> <li>7.5% HP + % nif ACP + % nif potassium nitrate + % nif fluoride</li> <li>9.5% HP</li> <li>7.5% HP</li> <li>35% HP</li> <li>38% HP</li> </ol>	7.5% and 9.5% HP: 30 min/d, 21 d 35% and 38% HP: 24 min (3 x 8 min), 3 sessions, 1-wk interval	Artificial saliva	Hardness, roughness	Before, during, immediately after, 1 and 2 weeks after bleaching	No difference in hardness or roughness vs pretreatment
Grobler et al 2011	HE, clinical trial	10% CP + % nif ACP + % nif potassium nitrate + % nif fluoride	Overnight or 4-6 h/d, 14 d	-	Sensitivity	Before, immediately after, 1, 3, and 6 months after bleaching	No reported sensitivity
Cavalli et al 2010	HE, <i>in vitro</i>	<ol style="list-style-type: none"> <li>10% CP + 0.2% calcium chloride rate</li> <li>10% CP + 0.2% sodium fluoride</li> <li>10% CP + 0.25% sodium fluoride + 0.5% potassium nitrate</li> <li>10% CP + % nif fluoride</li> <li>10% CP</li> <li>Placebo gel</li> </ol>	6 h/d, 14 d	Artificial saliva	Mineral loss, hardness	Before, soon after bleaching	Minimization of mineral loss; no difference in hardness vs pre-treatment

Contd...

Publication	Substrate, study design	Gel + mineral	Exposure time	Storage medium	Adverse effects evaluated	Evaluation timepoints	Effect of mineral addition
Cavalli et al 2011	HE, <i>in vitro</i>	1. 10% CP + 0.2% calcium chloride rate 2. 10% CP + 0.2% sodium fluoride 3. 10% CP 4. placebo gel	6 h/d, 14 d	Remineralizing solution (1.5 mM CaCl <sub>2</sub> , 0.9 mM Na <sub>2</sub> PO <sub>4</sub> , 0.15 mM KCl; pH 7)	Mineral loss	Immediately after bleaching	Minimization of mineral loss
Matis et al 2007	HE, clinical trial	1. 15% CP + 0.5% potassium nitrate + 0.25% sodium fluoride 2. 16% CP + % nif ACP + % nif potassium nitrate + % nif fluoride 3. 16% CP	Overnight or 4-6 h/d, 14 d	—	Sensitivity	7, 14, 21, 35, and 90 d after treatment initiation	No reported sensitivity
Janurudin et al 2006	HE and HA, <i>in vitro</i>	1. 34.5% HP + 15% HA 2. 34.5% HP 3. HA	24 h	—	Morphological changes	Immediately after bleaching	Accumulation of granules suggestive of minerals
Oliveira; Paes Leme; Giannini 2005	HE, <i>in vitro</i>	1. 10% CP + 0.05% calcium 2. 10% CP + 0.1% calcium 3. 10% CP + 0.2% calcium 4. 10% CP + 0.2% sodium fluoride 5. 10% CP + 0.5% sodium fluoride 6. 10% CP	6 h/d, 14 d	Artificial saliva	Hardness	Before, during, immediately after, 7 d after treatment	Decreased hardness
Ginger et al 2005	HE, clinical trial	1. 16% CP + 0.5% ACP + % nif calcium nitrate + % nif potassium pyrophosphate 2. 16% CP	3 h/d, 14 d	—	Sensitivity	During, immediately after, 5 d after treatment	Minimized sensitivity vs pretreatment
Browning et al 2004	HE, clinical trial	10% CP + 0.25% sodium fluoride + 0.5% potassium nitrate	6 h/d, 14 d	—	Sensitivity	Before, during, immediately after, 13 and 26 wk after treatment	Minimized sensitivity vs pretreatment
Tam 2001	HE, clinical trial	1. 10% CP + 3% potassium nitrate + 0.1% fluoride 2. 10% CP	Overnight or 4-6 h/d, 14 d	—	Sensitivity	Before, during, immediately after bleaching	Minimized sensitivity vs pretreatment
Giannini 2006	HE, <i>in vitro</i>	1. 10% CP + 0.2% sodium fluoride 2. 10% CP + 0.5% sodium fluoride 3. 10% CP + 0.05% calcium chloride rate 4. 10% CP + 0.2% calcium chloride rate 5. 10% CP	6 h/d, 14 d	Artificial saliva	Cohesive enamel strength	Immediately after bleaching	No change in tensile strength
Attin et al 2007	BE, <i>in vitro</i>	1. 10% CP + 0.5% sodium fluoride, pH = 7 2. 10% CP + 0.5% sodium fluoride, pH = 5.5 3. 10% CP, pH = 7 4. 10% CP, pH = 5.5	8 h/d, 7 d	Artificial saliva	Hardness	Before, during, immediately after, 5 d after bleaching	Reduced hardness immediately after bleaching; returned to normal after 8 d in artificial saliva
Borges et al 2012	HE, case report	1. 35% HP + 2% CPP-ACP 2. 35% HP	45 min (3 x 15 min), two sessions, 1-wk interval	-	Sensitivity, morphological changes	Before, immediately after bleaching	Decreased sensitivity, protection of enamel against morphological changes

HA: Hydroxyapatite; HE: Human enamel; BE: Bovine enamel; HP: Hydrogen peroxide; CP: Carbamide peroxide; CPP-ACP: Casein phosphopeptide-amorphous calcium phosphate; wk: Week; h: Hour; min: Minute; d: Day; ACP: Amorphous calcium phosphate

contents of 0.5 to 5% CPP-ACP, 0.5% ACP, or 0.1 to 0.25% sodium fluoride. Whitening protocols varied widely among studies, but the use of clinical or home application did not produce any discrepancy in results. Only some of these studies used control groups, which facilitated the interpretation of results through comparison with postbleaching data.

Three *in vitro* studies<sup>6,13,21</sup> evaluated morphological alterations of human enamel and HA surfaces. Gels containing 5.3 to 16% carbamide peroxide or 3.25 to 35% HP with added CPP-ACP or HA were used. All studies had control groups, and whitening protocols differed. Two studies reported the accumulation of granules suggestive of minerals<sup>6,21</sup> and one article noted no change in the enamel surface.<sup>13</sup>

Only one *in vitro* study<sup>22</sup> evaluated the cohesive strength of human enamel submitted to traction forces, after bleaching with 10% carbamide peroxide gel alone (control group) and gels containing various concentrations of sodium fluoride and calcium hydrochloride. The storage medium was artificial saliva and the bleaching protocol was 6 hours/day for 14 days. The author observed no reduction in enamel cohesive strength and concluded that the addition of minerals to whitening gel can increase the resistance of tooth enamel.

## DISCUSSION

Many studies of the effects of bleaching products on mineral loss in dental tissues used microhardness tests to evaluate the mineral contents of teeth<sup>23,24</sup> and to assess organic and inorganic changes after bleaching treatments.<sup>25</sup> The effects of bleaching agents on the microhardness of dental tissues, particularly enamel, remain controversial.<sup>23,26</sup> Scanning electron microscopy has shown alterations of the enamel surface, including the presence of erosion and porosities<sup>27-29</sup> and demineralization of the peripheries of enamel prisms,<sup>30,31</sup> after bleaching treatments. However, other studies have not confirmed these observations.<sup>29,32-34</sup>

The results of this review should be interpreted with caution, because no single study directly evaluated all parameters. However, the data provide a starting point for interpretation of the results of future studies and the design of future experiments evaluating the effects of mineral addition to whitening gel on dental enamel hardness.

De Vasconcelos et al<sup>6</sup> and Borges et al<sup>7</sup> observed increases in the hardness of dental enamel following the use of whitening gel containing CPP-ACP. Statistical analysis revealed significant differences ( $p < 0.05$ ) in hardness values obtained before and after bleaching, leading to the conclusion that this mineral can increase enamel hardness when used with home or in-office bleaching. The increased post-bleaching microhardness for samples bleached using peroxides with CPP-ACP suggests a mineral deposition on

enamel. It is likely that this mineral gain was also favored by the synergist effect of fluoride contained in the peroxides with CPP-ACP on enamel remineralization.<sup>6</sup> Some studies<sup>15,38,39</sup> examining other minerals did not obtain similar results, instead reporting the maintenance of or decrease in hardness values. In fact, differences between materials and protocols tested might justify these different findings.

One study<sup>6</sup> of bleaching agents containing CPP-ACP reported significantly increased enamel surface roughness after bleaching treatment. This result may be due to mineral deposition on the enamel surface, as observed on SEM images.<sup>6</sup> In contrast, Abreu et al<sup>15</sup> found no difference in enamel roughness following bleaching with a gel containing ACP ( $p > 0.05$ ). This result can be attributed to the ability of CPP-ACP to prevent and/or reverse enamel demineralization caused by bleaching agents. CPP-ACP may have a greater potential than ACP to affect enamel surfaces.

To prevent adverse effects, such as mineral loss,<sup>35,36</sup> different carbamide peroxide formulations have been developed and the addition of F and/or Ca to bleaching agents has been studied.<sup>22,37-39</sup> Two studies included in this review evaluated carbamide peroxide gels containing Fluoride and/or Ca using the same research protocol, and found that these products reduced mineral loss.<sup>19,20</sup> The addition of F or Ca ions may saturate the bleaching agent and these ions may be taken up by enamel through ion exchange, increasing resistance to acid and minimizing this adverse effect.<sup>19</sup> In contrast, other authors observed that fluoridated bleaching agents had no influence on the remineralization of pre-demineralized bovine enamel.<sup>40</sup> Fluoride ions enhance crystal growth and retard the dissolution of enamel mineral because of their participation in the solution phase, which increases supersaturation and decreases subsaturation.<sup>41</sup> Chemical analysis of rinse water can be used to determine Ca and F concentrations and indirectly demonstrate the gain or loss of ions on enamel surfaces.<sup>19</sup> Room-temperature Raman spectroscopy is the most sensitive and accurate method of chemical analysis, providing important information about ionic changes in enamel. This method is a simple and non-destructive means of obtaining information about the molecular composition and structure of the substrate.<sup>42</sup> Other methods include the cross-sectional analysis of microhardness and polarized light microscopy, which enables visualization of the early stage of demineralization.<sup>43</sup> The remineralizing solutions used in several studies included in this review may have contributed to the repair of microstructural defects promoted by bleaching agents through absorption and precipitation of salivary components, such as Ca and phosphate,<sup>37</sup> thereby reducing mineral loss, optimizing the action of minerals added to bleaching gels, and showing the importance of human saliva in the remineralization of tooth enamel.



Some authors have claimed that mineral loss is not a threatening factor, because similar ion loss has been observed after the exposure of enamel to soda or juice for a few minutes.<sup>44</sup> However, enamel is exposed to bleaching agents for hours each day during a period of up to 2 weeks. Over-exposure to bleaching agents, even at low concentrations, should be avoided and professionals should be alert to the possibility of microstructural changes promoted by bleaching agents *in vitro*.<sup>20</sup>

Common adverse effects of tooth whitening are dentinal thermal sensitivity and gingival irritation, which vary among patients and products. The addition of several minerals, such as potassium nitrate, sodium fluoride, and ACP, is thought to reduce dentinal sensitivity,<sup>10</sup> thereby improving the patient's compliance and comfort during the bleaching treatment.<sup>14</sup> All studies included in this review that evaluated this parameter found no or minimal postoperative sensitivity. Not all studies used control groups, but those that did found that most bleaching gels with added minerals, such as ACP,<sup>44</sup> F,<sup>14</sup> or CPP-ACP,<sup>13</sup> reduced sensitivity compared with the control group. Only Matis et al<sup>9</sup> reported no sensitivity compared with the control group. Studies with no control group reported no sensitivity after treatment with gels containing CPP-ACP<sup>13</sup> or ACP, potassium nitrate, and F.<sup>46</sup> Amorphous calcium phosphate rapidly obliterates dentinal tubules through rapid precipitation of calcium phosphate crystals on the enamel surface and within the tubules.<sup>47,48</sup> ACP<sup>47</sup> and potassium nitrate<sup>49,50</sup> have been suggested to reduce tooth sensitivity by preventing repolarization after initial depolarization, thereby reducing the sensory activity of dental and pulp nerves. Dentists have used F, which is also added to toothpastes, gels, and mouthwashes, to reduce dentinal sensitivity. The proposed mechanism of this effect is the occlusion of dentinal tubules by F precipitation.<sup>51-53</sup> The use of a 11% carbamide peroxide gel with no CPP-ACP has resulted in no sensitivity.<sup>57</sup> Studies included in the present review that tested 10% carbamide peroxide and 35% HP bleaching gels containing CPP-ACP found no or reduced sensitivity after bleaching, suggesting that bleaching gels containing CPP-ACP can reduce sensitivity.<sup>13</sup> Data reported in the reviewed studies indicate that the addition of minerals to bleaching gels is an important means of minimizing or eliminating dentinal sensitivity without compromising the quality of tooth bleaching treatments.

The authors of one study<sup>6</sup> that evaluated morphological changes in enamel via SEM after bleaching with 16% carbamide peroxide and 7.5% HP gels with different concentrations of CPP-ACP attributed the accumulation of granules suggestive of minerals on tooth enamel to this mineral. Depressions and irregularities were observed on enamel surfaces in the control group, which was treated

with bleaching gel alone. In this case, increased roughness due to CPP-ACP deposition was not considered a negative effect due to the benefits of CPP-ACP on dental tissues.<sup>6</sup> In contrast, another study found that gels containing CPP-ACP resulted in no change to the enamel surface, suggesting that this mineral protected the enamel from potential morphological changes caused by the whitening gel.<sup>13</sup> However, the use of an alternative bleaching protocol (three 15-min applications of 35% HP gel in two office sessions) in that study may explain the difference in results from those of De Vasconcelos et al.<sup>6</sup> The authors of a third study<sup>21</sup> attributed the deposition of granules suggestive of minerals (observed by SEM) on human enamel to the HA content of a 34.5% HP gel. In contrast, SEM images of specimens from the control group (34.5% HP gel alone) in that study showed the destruction of tooth surfaces. Hydroxyapatite [ $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$ ], a ceramic used in medical and dental applications and added to toothpastes, has excellent biocompatibility with human bone, epithelial tissue, and gingiva.<sup>54</sup> Guo et al<sup>55</sup> proposed that HA can mineralize the tooth surface in the presence of saliva when used as an abrasive agent in toothpaste or as an enamel strengthening agent. The addition of HA to bleaching gel increased the gel's efficiency.<sup>21</sup> Additional studies should be conducted to further evaluate the effects of the addition of this mineral to whitening gel.

Giannini et al<sup>22</sup> observed no difference in the tensile strength of enamel bleached with 10% carbamide peroxide gel containing sodium fluoride or calcium hydrochloride, but reduced strength in enamel treated with whitening gel alone. Bleaching gels containing F or Ca are thought to increase the saturation of the gel, reducing mineral loss and increasing enamel resistance to demineralization caused by peroxides.<sup>22</sup> Unbleached enamel specimens subjected to forces parallel to the orientation of enamel prisms show a typical cross-fracture pattern<sup>56</sup> and a compact structure with no porosity.<sup>22</sup> Scanning electron microscopy observation of specimens bleached with carbamide peroxide gels containing F or Ca showed similar patterns, with small differences among Ca, F and control groups. Thus, these products do not affect the strength or mechanical properties of enamel.

Taking together the results of all studies evaluated in this review, and despite the limitations of not having been assessed studies *in situ* and the lack of evaluation of adverse effects of all possible combinations of gels and minerals, the addition of minerals to bleaching gels emerges as a factor of paramount importance to minimize the adverse effects of dental bleaching. The reduction or elimination of such adverse effects optimizes patient comfort and compliance, enhances enamel protection, and may even increase the efficiency of bleaching gels, as shown by Janurudin et al.<sup>21</sup> Further studies should be performed to confirm the latter effect.

## CONCLUSION

The findings of this review suggest that the addition of minerals to bleaching gels can potentially reduce the most adverse effects of tooth bleaching, probably without affecting the efficiency of bleaching gels or changing the hardness or morphology of the substrates studied. The addition of CPP-ACP to dental bleaching gels contributes to increased enamel hardness and roughness, and may protect enamel from morphological changes or induce the accumulation of granules suggestive of minerals. Hydroxyapatite, which has also been reported to result in granule accumulation, may improve the efficiency of bleaching gels, but additional studies are needed to confirm these claims. Calcium and F can minimize mineral loss and prevent a reduction in the tensile strength of tooth enamel. Moreover, all relevant studies reported that the addition of minerals to bleaching gels prevented post-bleaching dental sensitivity without interfering with the quality of tooth bleaching. Additional *in situ* studies should be performed to confirm the results reported to date regarding the ability of minerals to minimize the adverse effects of bleaching gels on dental enamel. In addition, clinical trials should be conducted to validate the findings related to sensitivity and the effects of minerals on bleaching efficacy. Dentistry is varying with induction of modern science to practice dentistry.<sup>58</sup>

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