

## Tooth Whitening in Children and Adolescents: A Literature Review

Sean S. Lee, DDS<sup>1</sup> Wu Zhang, MD<sup>2</sup> D. Harvey Lee, DDS, MPH<sup>3</sup> Yiming Li, DDS, MSD, PhD<sup>4</sup>

### Abstract

The purpose of this paper was to summarize the findings of a literature review on the use of peroxide-based tooth-whitening agents in children and adolescents. Safety considerations, including localized adverse effects and toxicological concerns, are described. Oral findings include: (1) 1 in every 2 to 3 patients may experience tooth sensitivity and/or gingival irritation after bleaching treatment, which may be more traumatic an experience for children than adults; (2) depending on dose, duration, frequency, and route, studies indicate excessive exposure to peroxide can be potentially harmful; (3) degree of potential toxicity and harmful outcomes increases in those who overuse whiteners—a concern in teenagers; (4) careful case selection using stringent criteria is suggested for primary teeth whitening; (5) whitening in healthy adolescents is a case-by-case determination that must include the weighing of risks (oral health and age) vs benefits (improved esthetic perception). It is hoped that the present review will lead to a better understanding of the health implications of tooth whitening in children and adolescents, and offer guidance for treatment that provides satisfactory outcomes externally (enamel and gingiva) and internally (endodontic tissues and systemic health). (*Pediatr Dent* 2005; 27:362-368)

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Hydrogen peroxide ( $H_2O_2$ ) is found in the environment and the human body<sup>1</sup> and is used for industrial applications. For example, it is used in the processing of foods and drinks like fruit juice, wine, and coffee.<sup>2,3</sup> In the body,  $H_2O_2$  is an intermediate metabolite<sup>4</sup> produced by the liver and phagocytic cells that is found in human serum and even in human breath.

Although peroxide has been deemed safe and effective in dentistry as a tooth whitener for adults, a much smaller number of safety and efficacy studies have been conducted on children.<sup>5-10</sup> For both children and adults, there is a dearth of reports in the literature on systemic safety. Rather, the existing in vivo studies use animal models. Of the stud-

ies on children, the adverse effects investigated have been limited to the localized effects of tooth whitener use.<sup>6</sup>

Meanwhile, a greater number of pediatric patients are reportedly requesting tooth bleaching in recent years.<sup>7</sup> Sales of over-the-counter (OTC) tooth-whitening products grew 57% in 2003.<sup>11</sup> A 2004 literature search could not locate any studies done to determine if teenagers overuse whiteners. The potential for abuse, however, is present. One pediatric dentist who reported that more of his teenage patients complain of tooth sensitivity from tooth whitening than his 7- to 11-year-old patients who undergo the procedure theorized that teens may be using the home bleaching agents more frequently than directed to get faster results.<sup>6</sup> In one study, many children—some as young as 10—wore their tooth whitener strips on the way to school in the morning.<sup>7</sup> On weekends, however, it is unknown if these same children wear these strips longer.

Interestingly, a survey of all American dental schools found that 92% teach nightguard bleaching.<sup>12</sup> The 8% that are not teaching it cite lack of curriculum time and safety concerns. Schools teach their students that, on the average, 25% of patients will develop sensitivity, while reports in the literature indicate 50%.<sup>13</sup> Reported approaches to treat tooth sensitivity included reducing exposure time,

<sup>1</sup>Dr. S. Lee is director, Clinical Research Program, Center for Dental Research, and assistant professor, Department of Restorative Dentistry;

<sup>2</sup>Dr. Zhang is associate professor and director, Sterilization Assurance Service, Department of Dental Educational Services; <sup>4</sup>Dr. Li is

director, Center for Dental Research, and professor and director, Biocompatibility and Toxicology Research Laboratory, Department of Restorative Dentistry, and professor, Department of Microbiology and Molecular Genetics, all at Loma Linda University, Loma Linda, Calif; <sup>3</sup>Dr. H. Lee is a pediatric dental resident, St. Barnabas Hospital, Bronx, NY.

Correspond with Dr. Lee at seanlee@llu.edu

administering a fluoride treatment, and recommending a desensitizing dentifrice.

The purpose of this article was to review literature on child and adolescent tooth whitening, including usage trends, side effects, safety concerns, and carcinogenesis. Suggestions for safest use in children and adolescents are also included.

### Primary teeth whitening

Although tooth bleaching has been performed over the years in children as young as age 4,<sup>9</sup> it is rarely done in children younger than 6.<sup>8</sup> It may be indicated for those children who report (or parents who report) that tooth discoloration "is bringing negative attention."<sup>14</sup> Similarly, some researchers advocate whitening for young permanent teeth, even when they are only partially erupted with incomplete root formation, because "even young patients can be highly concerned over discoloration of their anterior teeth."<sup>15</sup>

In a 2004 study, 32% of a group of 2,495 children were dissatisfied with their tooth color, 19% of parents were dissatisfied with their child's tooth color, and only 9% of dentists felt the subjects had unsatisfactory tooth color.<sup>16</sup>

Recommendations for children's whitening safety are essentially based on human research findings from studies utilizing adults. Few clinical studies on minor study subjects (especially those with primary teeth) have been performed, partially due to ethical reasons. The findings mostly depend on case reports in minor subjects. Hard tissue effects seen in *in vitro* studies of extracted primary teeth are extrapolated to vital teeth.

No evidence of lasting local or systemic effects has been observed in short-term studies. There have been no data to justify recommending against using whiteners in children. Caution, however, must still be taken. No studies published in peer-reviewed dental journals have stated that tooth bleaching is unquestionably safe for all children. Those that recommend it state that it is "considered safe" without directly measured systemic effects. Interestingly, although the advertised safety claims of OTC products are unsubstantiated by data (or only by data from studies that evaluated the OTC products under professional supervision), the market remains strong.<sup>17</sup> Conclusions regarding safe usage in pediatric whitening studies, therefore, are mostly based on short-term clinical observations and measurements and studies tabulating patient complaints. Currently, while there are dentist-dispensed and in-office tooth whiteners that have received the ADA's Seal of Acceptance,<sup>18,19</sup> their safety and effectiveness data were collected from adults, with no specific indication or descriptions on the use of these whiteners for children. Long-term evaluation is needed to reveal the consequences of repeatable use of tooth whiteners.

In the majority of tooth whiteners on the market, the peroxide concentrations range from approximately 3% to 38%. Meanwhile, peroxides in lower concentration have

been studied more extensively by researchers in general.<sup>20-22</sup> Because concerns linger over potential adverse effects,<sup>23-25</sup> factors for determining exposure include: (1) route; (2) dose; (3) tissue contact; (4) duration of each application; (5) frequency of treatment; (6) total number of applications; and (7) amounts swallowed and absorbed through any portals of injury.<sup>26,27</sup>

With primary teeth having thinner dentin and enamel and relatively larger pulps than permanent teeth,<sup>6</sup> increased sensitivity to peroxide would be expected in theory. This, however, does not appear to be consistent with limited clinical findings. One investigator reported more complaints from adolescent subjects than 7- to 11-year-olds.<sup>7</sup> The same and other reports suggested whether a larger pulp can recover from insult more rapidly, because the apex of the tooth is also larger.<sup>6</sup> It is unclear whether the age difference itself has an effect on the willingness to report the sensitivity among these 2 groups.

### Whitening safety considerations unique to primary, mixed, and permanent teeth in children

Characteristics of the primary dentition include:

1. crowns shorter in length relative to total tooth length compared with permanent teeth;
2. enamel whiter than that of permanent teeth;
3. primary crowns with a milk-white color.

The characteristics of permanent dentin in young adolescents are closer to that of adults than the primary dentition, but may still be thinner by comparison. The maxillary cuspids of adolescents may not erupt until age 12 or 13, and enamel calcification takes approximately another 2 years. Moreover, children's teeth are easier to bleach than adult teeth,<sup>28</sup> because enamel permeability decreases with age. The downside, however, is that their pulps may receive more exposure to peroxide as a result.

Subjects ranging in age from 15 to 30 years using 10% carbamide peroxide in a tray for 2 to 6 hours a day for 3 weeks also reported mild and transient local effects.<sup>29</sup> When used as directed by the manufacturer, no evidence is found in the literature to suggest a risk of any permanent adverse effect.<sup>30-34</sup>

One adolescent and 1 adult who improperly used whiteners did suffer permanent enamel disintegration and pitting.<sup>35,36</sup> Because of the potential for overuse or abuse, it is encouraging that, in a study with exaggerated use of 18% carbamide peroxide (4 applications daily for 2 weeks), the adverse effects were mild and resolved without medical intervention.<sup>37</sup>

### Effects on microhardness

In an *in vitro* study using 105 human dentin slabs and 6 proprietary bleaching products, depending on the product applied, the microhardness test results showed that dentin may become demineralized. This results in a decrease in microhardness values. Posttreatment values, however, returned

to normal. This indicates a remineralizing effect of the artificial saliva, which would be expected with human saliva.<sup>38</sup>

Another enamel microhardness investigation<sup>39</sup> showed no significant difference between the exposed specimens and the controls. Any morphological topographical characteristics seen in the exposed specimens were also seen in the controls. These findings are consistent with other studies showing no negative effects of whitening on dentin or enamel.<sup>39</sup>

Although calcium loss was observed in *in vitro* studies of bleaching with carbamide peroxide on human enamel,<sup>40</sup> the clinical significance of calcium loss is not known. One study stated that excessive whitener use can cause overoxidation, thereby "breaking down the tooth structure."<sup>41</sup> Primary teeth, which contain more organic material and less mineral content than permanent teeth, would, therefore, be at greater risk for demineralization than permanent teeth.<sup>42</sup> Further studies to investigate this concern are needed.

Since the *in vitro* findings of carbamide peroxide—exposed primary teeth are similar to permanent teeth—it is tempting to deem whitening them "risk-free." Indeed, the literature largely views peroxides and carbamide peroxides as an effective option for lightening stained teeth in children.<sup>7,43</sup> Some *in vivo* research efforts have been made to determine localized effects. An 18-month follow-up of intracoronal whitening of nonvital teeth in children ages 11 to 16 years proved reassuring, for example, as it found no cervical or root resorption.<sup>39</sup>

Retaining some treatment limitations, however, is prudent with young patient populations. Whitening of primary teeth should always be provided or authorized by dentists. There are many reasons that cause teeth staining. Simply using OTC products may delay the necessary treatment. Because minors usually want fast results when whitening their teeth and there is an unlimited access of whiteners to them, there is a chance of systemic exposure to peroxide due to a large dose ingestion of H<sub>2</sub>O<sub>2</sub>, even though the ingestion of whiteners has not been a significant concern. Dental clinicians should use stringent case selection criteria. For example, if a child is suffering emotionally from negative attention because of badly stained teeth, the parent would agree to closely supervise on its use, sign an informed consent, and the child would also need to maintain good oral and general health.

With low doses, proper exposure frequency, and short duration, tooth bleaching may not damage the surface of the enamel of primary, mixed, or permanent dentition of children. Home use of whiteners, however, remains a concern because dentists have less control over the amount of time that their teenage patient may actually be using or abusing the product.

#### **Carcinogenicity concerns**

During the last 2 decades, there have been concerns regarding potential carcinogenicity of hydrogen peroxide. So far, however, there is inadequate evidence regarding the carci-

nogenicity of hydrogen peroxide in humans.<sup>44</sup> While carcinogenicity or cocarcinogenicity of hydrogen peroxide have been reported by several investigators, the data supporting the conclusion were found to be weak or unsubstantiated.

In 1986, Weitzman et al tested on Syrian hamsters' epithelia, which was painted with 30% hydrogen peroxide twice a week for 22 weeks. This resulted not in tumors, but in preneoplastic changes such as hyperkeratosis and hyperplasia in all the animals and hyperchromatic cells and mild dysplasia in almost half of the hamsters.<sup>45</sup> It should be pointed out that carcinomas were not produced by using lower concentration of peroxide.<sup>46</sup> So far, available scientific evidence does not support the concern of carcinogenicity of hydrogen peroxide.<sup>47</sup>

In another study<sup>48</sup> of 4 mice strains given 0.4% hydrogen peroxide as drinking water for the first 6 months of life, researchers tentatively identified from 11% to 100% of mice that had developed duodenal tumors (hyperplasia or neoplasia). Yet, sounding the warning bells—by concluding from these studies and others that hydrogen peroxide whiteners are responsible for causing cancers or promoting lesions already present—is not supported. Some researchers who had issued warnings later retracted them, stating they were "premature."<sup>49</sup> Similarly, more recent reports linking bleaching agents to ionizing radiation in terms of their generation of biological effects<sup>50</sup> and to oral cavity squamous cell carcinoma<sup>51</sup> were also quickly found unsubstantiated.

### **Suggested approaches for pediatric tooth whitening**

#### **Dentist and parent-supervised bleaching**

The review of the literature clearly shows a dearth of human safety studies of whitening for primary and mixed dentition. A study shows that younger children are significantly more critical of their anterior teeth shade than older children.<sup>16</sup> So far, there are no commonly accepted or agreed-upon approaches for children's tooth whitening. Such treatments, however, are being practiced increasingly. Therefore, it is imperative to establish proper approaches for maximum benefits and minimum side effects.

One of the suggested approaches is that tooth bleaching should be done only under strict supervision of the dentist and parent. Compliance problems in younger children discourages at-home tooth whitening.<sup>9</sup> Informed consent should be obtained, and a signed document should be kept on file. Each patient's health history should be carefully evaluated and the possible risks and benefits should be discussed with both parents or guardians. Lower concentrations of peroxide or carbamide peroxide should be used, and treatment should be frequently repeated.

In 1993, Haywood reported that there were probably no indications for primary teeth whitening<sup>52</sup>—a position on which the authors agree. In 2004, the American Academy

of Pediatric Dentistry (AAPD) adopted a policy on dental bleaching for child and adolescent patients. The AAPD encourages the judicious use of bleaching for those patients and discourages full-arch cosmetic bleaching for the patient in mixed dentition.<sup>53</sup>

#### **Whitening recommendations for young adolescents**

Compared with placing restorations to solve a tooth discoloration problem, whitening is a conservative treatment option. An example would be a 13-year-old who is socially distressed to the point of trying not to smile because of a dark nonvital central incisor resulting from trauma. For those with orthodontic appliances, after removal discolored enamel regions or darkened teeth may be revealed because of the inability to brush well under braces.<sup>54</sup> Yet, compared with bonding, veneers, or crowns, whitening is the most conservative treatment option.<sup>55</sup> Although sodium hypochlorite has been recommended in the last decade, it is not yet a widely accepted modality.<sup>15,56,57</sup>

The authors recommend:

1. delaying dispensing at-home use whitening treatments to adolescents until age 14 or 15, if possible, to avoid potential toxicity risks via abuse;
2. using a custom-fabricated tray<sup>17</sup> to minimize the necessary amount of whitening gel;
3. using less than half of a gram of a 10% carbamide peroxide whitening gel, preferably a product with the ADA Seal of Acceptance,<sup>5</sup> for approximately 10 teeth.

About 10% of the gel may be swallowed. This exposure dose should be no more than the equivalent of 5 mg of carbamide peroxide for each treatment.

#### **Oral and other conditions that contraindicate tooth whitening**

Some of the conditions that either need to be resolved or taken into consideration before bleaching so that adaptive strategies may be considered include:

1. dry mouth;
2. enzymatic disorders;
3. respiratory or digestive tract disorders;
4. asthma;
5. allergy to vinyl;
6. hypersensitivity to hydrogen compounds;
7. mouth breathing;
8. unrestored tooth decay;
9. frankly exposed root surfaces;
10. broken teeth;
11. severe enamel erosion due to acidic or carbonated drink intake or gastric regurgitation (eg, bulimia);
12. parafunctional grinding;
13. poor oral hygiene.

The study by Marshall et al<sup>58</sup> indicated that even infants can clear at least 30 mg of hydrogen peroxide in their oral cavity in 1 minute. Saliva deficiency in the mouth, however, may cause problems.

As for adult trays, children's whitening trays can be gently cleaned with cold water and a soft toothbrush using the manufacturers suggested mild soap solution, diluted mouthrinse, or toothpaste. After it is dried, it should be stored in a sturdy container until the next use to avoid unexpected distortion and contamination of the trays.

#### **Reminders for parents**

Before pursuing whitening treatment, parents should be made aware that their child (especially teenagers) may expect an unrealistically fast-occurring and whiter shade change. If a high concentration of hydrogen peroxide and light activation are used, posttreatment sensitivity may be profound, according to researchers. This intense sensitivity, however, will mostly dissipate in 24 hours.<sup>59</sup> Although it is not referring specifically to children, this report of a "slowing-down effect" during bleaching treatment is useful information. It is recommended to continue whitening for a total of 2 weeks. Whitening time of an individual treatment should not be extended in an attempt to increase effects. This allows whitening material more of an opportunity to penetrate into the pulp. The highest concentration of peroxide should be avoided if possible, as the potential adverse effects on the pulp are not well-established in adults, let alone children.

To prolong the bleaching effects, a whitening toothpaste can be used. This can help sustain improvement and slow the reversion back to its original shade—especially for children who eat dye-laden candy. Even colas and fruit sodas can restrain newly lightened teeth. Yet, since some whitening toothpastes contain abrasives, they are best for short-term or occasional use. Moreover, temptations to exert extra strength in brushing must be discouraged due to the abrasives contained therein.

#### **Fluoride treatments after whitening**

Although the evidence on its benefits is contradictory, neutral sodium fluoride solution can be applied to the tooth or teeth after completion of a whitening regimen to encourage remineralization without any adverse effects. One pediatric whitening researcher reported clinical observation of less noticeable shade reversion in his patients who had received fluoride treatment vs those who did not.<sup>6</sup> In fact, recent research shows that, if higher concentrations of carbamide peroxide are used in whiteners, a miniscule but measurable decrease in enamel microhardness can occur. This research also shows that using less acidic pH products may lessen this effect.<sup>60</sup> Also, using products containing fluoride may help recover microhardness and, thus, have a less hazardous effect on enamel's mineral content.<sup>60</sup>

#### **Monitoring and patient/parent education**

While peroxide-containing products, including tooth-whitening products, have long been used with little risks, adequate caution needs to be taken to ensure their safe use.

Adverse effects, both systemic and local, have been reported due to the inappropriate use or abuse of these products. Thus, the authors again emphasize that dentist-dispensed home-use whitening systems also need to be monitored for effectiveness and safety by a dentist and used with direct parental supervision for all children and adolescents and those with cognitive impairments. This will help avoid excessive peroxide exposure via swallowing and spillage onto soft tissues. Patients may be cautioned that—should they choose to purchase OTC products applied via tray, brush-on, or strip—consulting their dentist<sup>53</sup> about which product to try and the safety, effectiveness, and proper use of those products is recommended. By trying OTC products without a dentist's advice, patients may not only experience disappointments when anticipated benefits are not achieved, but pain and unsightly, uneven shade changes to the enamel may also occur as a result of surface damage.

### Discussion

More research is needed to definitively establish appropriate use and limitations of use and to investigate systemic toxicity implications related to repeated use and dosage in children. A trend of increasing hydrogen peroxide concentrations is occurring among OTC bleaching products and also to use among dentist-dispensed and OTC products designed for periods longer than 2 to 4 weeks. Because of this and the fact that whitener overuse or extended-use studies have not been done on children, our government should ban selling OTC bleaching products to minors. Tooth whiteners are classified by the US Food and Drug Administration as "cosmetics," not "drugs," which means they don't have to adhere to stringent rules such as providing dose-body weight packaging directions.

During the last few years, the US Environmental Protection Agency has been studying whether there are conclusive differences between children and adults in terms of cancer risks from exposure to the same mutagenic agents. As of 2003, it had been assumed the risks were the same.<sup>61</sup> A 2004 EPA report, however, concluded that the available scientific data shows there is a higher risk of cancer from childhood exposure than the same exposure during adulthood.<sup>62</sup> Between the ages of 2 to 15 years, therefore, exposure to agents containing mutagens or carcinogens should be adjusted by 3-fold as a protective measure.

The EPA is also assessing new conceptual dose-response models for chemical noncarcinogenic toxicants in children.<sup>63</sup> Such an effort aims to get to the bottom of questions such as how early exposure to toxicants alter the development of organ systems and their functions and the immune system that could affect cancer later in life. It is unclear what impact—if any—the EPA's latest focus on the relevance of age and chemical exposures will have upon dental research and treatments in children. Further research on the potential of nitrate's interactions and teenagers' metabolism would provide data of interest.

Research is needed to determine answers to several important questions. For example, how are genotoxicity and carcinogen concerns of peroxide exposure different in children vs adults? How can we know with certainty that long-term daily use of tooth whiteners in children can't trigger ill effects over time? Can surface changes from whitening create uneven restaining? Do hard tissue and pulpal changes contribute to lasting thermal tooth sensitivity? Do repeated treatments assault the pulp and take a toll on its longevity?

### Conclusions

Conservative treatment is in order for all children and adolescents. Should a healthy adolescent patient with permanent teeth under age 15 desire bleaching and have unique circumstances that qualify him or her as an appropriate whitening candidate, informed consent from a parent or guardian must be obtained.

Much more research is needed on the local and systemic actions and the results of hydrogen and carbamide peroxide in children's tooth bleaching products. The data from future children's tooth-whitening studies may result in shortened exposure times and less frequent applications needed to achieve a comparable result to that of an adult without risking the unknown hazards. Determining the duration and concentration regimens more appropriate for children based on age and dentition type is in the best interest of dentistry and the health of our future adults.

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