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An overview on the Effects of 10% and 15% Carbamide Peroxide and its Relationship to Dentine Sensitivity

ABSTRACT

The purpose of this overview was to review the available literature to determine if there was any evidence that the application of 10% and 15% carbamide peroxide in tooth whitening procedures resulted in tooth (dentine) sensitivity. The conclusions from the review would indicate that tooth whitening with either 10% or 15% carbamide peroxide is an effective and safe treatment when under a dental professionals' supervision. Reported side-effects were considered mild to moderate in nature and were transient in duration. Reported incidences of dentine sensitivity range from 15-65% of patients using 10% carbamide peroxide.

INTRODUCTION

According to Joiner¹ the aesthetics or appearance (including tooth colour) of teeth is of great importance to patients. It has been reported that in the UK 28% of adults are dissatisfied with the appearance of their teeth² whereas in the USA 34% of an adult population were dissatisfied with the colour of their teeth.³

Currently four different approaches to vital tooth whitening have been recommended^{4,5} and these are:

- 1) The use of a high concentration of hydrogen peroxide (HP) or carbamide peroxide (CP) (Dentist- administered bleaching),
- 2) A bleaching tray: used with high concentrations of carbamide peroxide (In-Office Dentist-supervised bleaching),
- 3) At home or night guard bleaching: available in the form of a custom-made tray with a solution of carbamide peroxide at a lower percentage of active ingredients (Dentist-provided bleaching/patient administered)
- 4) Various concentrations of hydrogen peroxide or carbamide peroxide products available in pre-fabricated trays or whitening strips (Over-the-Counter (OTC) products available for administration by patients/consumers). (Table 1)

Tooth whitening can include both professionally dispensed products (whitening strips, trays,) and over-the-counter (OTC), patient-purchased products; for example, whitening tooth pastes, OTC bleaching products, routine dental prophylaxis, professionally dispensed vital bleaching products, non-vital tooth bleaching.⁶ There are, however a number of related adverse effects following tooth whitening procedures that have been reported (Table 2).

1- Cervical root resorption this is an inflammatory-mediated external resorption of the root, which can be seen after trauma and following intra canal bleaching.^{4,7}

2- Tooth (dentine) sensitivity is a common side-effect of external tooth bleaching.⁸ Tooth (dentine) sensitivity normally persists for up to 4 days after the cessation of bleaching treatment^{9,10} but a longer duration of up to 39 days has also been reported.^{11,12} Patients with a previous history of tooth (dentine) sensitivity may therefore have a higher risk for such an adverse effect from external tooth bleaching, and this should be taken into account before treatment begins.⁴ (Table 2)

3- Mucosal irritation

Studies have shown that high concentrations of hydrogen peroxide is an irritant and also cytotoxic in nature.¹³ For example, it is known that at concentrations of 10% hydrogen peroxide or higher, the chemical is potentially corrosive to mucous membranes of skin, causing a burning sensation and tissue damage.^{4,13,14,15,16,17}

4- Alteration of the enamel surface

Morphological alteration of the enamel following tooth bleaching has been identified in several studies.⁴

5- General side effects

Results from in vitro studies would suggest that dental restorative materials may be also affected by tooth bleaching agents.¹⁸ These findings relate to possible physical and/or chemical changes in the materials, such as increased surface roughness, crack development, marginal breakdown, release of metallic ions, and decreases in tooth-to-restoration bond strength.¹³

TOOTH WHITENING SYSTEMS

Tooth whitening with different concentrations of peroxide have been demonstrated to be safe and effective in a variety of regimens, including in-office procedures, dentist-prescribed and supervised home treatments and over the counter system approaches. (Table 3)

1. Self-applied systems

The most common regimen is the at-home use for 2 to 4 weeks, generally speaking the initial colour of the tooth would be recorded using a shade guide and subsequently reassessed at the end of the treatment to determine whether that had been a change in the colour of the tooth.^{19,20} According to Ames (1937) cited by Jorgenson & Carroll²¹ the use of hydrogen peroxide for removing intrinsic stains from vital teeth has been used for many years following the recognition of Fluorosis staining. Haywood & Heymann published the first article describing night guard vital bleaching in 1989¹⁹ where a bleaching tray was fabricated from a model of the teeth using a soft plastic material and subsequently loaded with a carbamide peroxide gel and seated over the teeth for approximately 2 hours. The advantage of the take-home systems was the

decreased cost, compared to the in-office bleaching options. The major disadvantages however, associated with take-home systems are that they require significant patient compliance with the number of applications usually involving 1-2 hours twice a day or overnight wear, and the entire treatment usually takes at least four weeks.

2. In-office (Professionally applied) systems

The most acceptable applications involved are in-office techniques, using hydrogen peroxide bleaching agent (heated or non-heated). For the purpose of the present paper only 10% and 15% concentrations will be considered. The advantages of the in-office procedure are that these procedures require minimal patient compliance, and immediate results are attainable. The disadvantages to this treatment are however, chair-time requirement, and a cost to the patient. It is important to note that this procedure usually requires multiple office visits.

Table 1: Different approaches to vital tooth whitening
Dentist- administered bleaching.
In-Office Dentist-supervised bleaching.
Dentist-provided bleaching/ patient administered.
Over-the- Counter (OTC) products available for administration by patients/consumers.

Table 2: Adverse effects following tooth whitening procedures:
1. Cervical root resorption
2. Tooth (dentine) sensitivity
3. Mucosal irritation
4. Alteration of enamel surface
5. General side effects

Table 3: Tooth whitening systems
1. Take home system
2. In-office system including power bleaching
3. Combination techniques including night guard vital bleaching
4. Whitening strips
5. Light activated whitening systems
6. Tooth paste
7. Over the counter products

3. Combination techniques

By combining the two techniques (in-office and take-home), there is a reduction in the amount of time and the need for repeated office visits as well as the expense associated with in-office bleaching as a stand-alone technique.²²

4. Whitening strips

Whitening strips containing 5.3% hydrogen peroxide in the form of an-impregnated polyethylene strip have been developed and compared to 10% carbamide peroxide. Although an evaluation of 5.3% hydrogen peroxide products are outside the remit of the present review the use of these strips have been recommended for maintaining the tooth colour of already whitened teeth. It may also be a good option for patients who cannot afford the cost of other whitening treatments or who do not have the time for multiple dental visits for tray fabrication.²³ Several investigators have also compared the effect of increasing the peroxide concentration (hydrogen and carbamide) on the colour of the tooth (tooth shade).^{24,25} These studies demonstrated that a modest increase in peroxide concentration on a flexible bleaching strip results in increased whitening effectiveness, without adversely impacting on overall tolerability. Sulieman *et al.*²⁶ also concluded that the whitening impact by both CP and HP home-use bleaching systems was rate and concentration dependant.

5. Light activated whitening systems

The introduction of light activated devices such as plasma arc, light emitting diodes (LED), argon laser, metal halide and xenon-halogen lights by dental manufacturers have helped create a public demand for the light enhanced tooth whitening systems. In order to reduce treatment time, clinicians have attempted to accelerate the degradation of hydrogen peroxide by using heat or light, Cohen and Parkins²⁷ introduced a technique for bleaching discoloured teeth using hydrogen peroxide and a hand-held heating source.¹²

6. Dentifrices

Various types of toothpaste formulations are commercially available as tooth whitening products, but only a small number have demonstrated stain removal ability and effectiveness. It would appear that most of these toothpaste formulations do not contain bleaching agents (e.g., peroxide) in their formulation. Of those toothpastes that do have very low concentration of peroxide, the contact times are too short to be effective.²⁸ Whitening toothpastes also contain mild abrasives to remove surface stains. The peroxide content in the toothpastes is generally very low (1% or less), and the exposure of these toothpastes on the tooth surface is minimal hence there would be a minimal whitening effect.²⁹

7. Over the counter products

Easy availability of the over the counter (OTC) whitening products have made the whitening of teeth more popular amongst individuals of all ages. There are different types of over the counter (OTC) products, for example whitening dentifrices, tray-based, whitening strips and most recently paint-on formulations to be applied by the patient with a brush. Over the counter bleaching kits generally require the consumer to use either a prefabricated tray or fabricate their own semi-moulded tray then fill it with supplied bleaching agents. These types are less than ideal because the trays are not custom fitted and the formulation is not as sophisticated as those dispensed by the dentist²⁷ and some have acid pre rinses that are destructive of tooth tissue.

DEVELOPMENT OF NIGHT GUARD VITAL BLEACHING

A successful home bleaching technique using hydrogen peroxide was first described by Klusmier in 1968³⁰ when it was observed that the teeth became whiter after treatment of a mouth injury with Glycoside (hydrogen peroxide mouthwash) in an orthodontic retainer. The results were lighter teeth in addition to the healing of the injury.

DEVELOPMENT OF POWER BLEACHING

“Power bleaching” is an in-office whitening technique developed to bleach teeth in a single office visit with a combination of a whitening agent such as hydrogen peroxide and an auxiliary source for example, light. Although these power gels could be controlled easily compared with the liquids used previously, full-mouth isolation was still needed to protect the gums and surrounding soft tissues. Power bleaching was frequently combined with home-use tray systems to maximize the bleaching effect and to give a ‘kick start’ to the whitening procedure before the patient continued with night guard vital bleaching at home.³¹

A further modification to the power bleaching system was the use of an argon laser as an activating light source to replace conventional curing lights.³² The present day systems are activated by a variety of light sources: plasma arc lamps, Xenon halogen, light emitting diode (LED) light and diode lasers. Light sources are not essential and there are systems that require chemical activation only and are painted onto the teeth with gingival and mucosal isolation.^{31,33}

MECHANISM OF ACTION OF TOOTH WHITENING

The exact mechanism of action is not completely understood. Hydrogen peroxide diffuses through the organic matrix of the enamel and dentine.^{34,35} Since the radicals have unpaired electrons, they are extremely electrophilic and unstable and will attack most other organic molecules to achieve stability, generating other radicals. These radicals can react with most unsaturated bonds, resulting in disruption of elec-

tron conjunction and a change in the absorption energy of the organic molecules in tooth enamel. Simple molecules that reflect less light are formed, creating a successful whitening action. This process occurs when the oxidizing agent (hydrogen peroxide) reacts with organic material in the spaces between the inorganic salts in tooth enamel.³⁶ The reported soft-tissue irritation as a common side effect of peroxide-based whitening procedures was however, mild and transient in nature.¹⁹ The original at-home bleaching products used a 10% solution of carbamide peroxide as the bleaching agent, in the form of 3% hydrogen peroxide and 7% urea. The urea in carbamide peroxide primarily acts as stabilizer to give these products a longer shelf life, slower release of the hydrogen peroxide, and reported additional cariostatic benefits.³⁷ It has also been suggested that hydrogen peroxide penetrates the tooth more quickly than carbamide peroxide. The basic mechanism of action is the same, but the formulation affects both the shelf life and time required for the penetration of the teeth.³⁸

BLEACHING RELATED SENSITIVITY AND PAIN: POSSIBLE MECHANISMS OF ACTION

According to Markowitz³⁹ although the hydrodynamic theory proposed by Brännström⁴⁰ is currently recognized as the underlying mechanism for dentine sensitivity a number of Investigators have suggested that bleaching sensitivity is a form of dentine sensitivity.⁴¹ It is, however more likely that the mechanisms are different, for example although pain reported from dentine sensitivity may be evoked by certain stimuli (thermal, evaporative etc.) patients undergoing bleaching procedures often complain of pain without any provocation from these stimuli. Furthermore, the pain experienced during the bleaching procedure may affect intact teeth lacking dentine exposure; this is in sharp contrast to dentine sensitivity where pain occurs in teeth with exposed dentine. Teeth with defects such as: caries, defective restorations,⁴² or exposed dentine has also been suspected of being more prone to bleaching sensitivity than intact teeth. These defects may therefore provide a direct diffusion pathway for peroxide to the deeper dentine structure.

It has also been suggested that oxygen bubbles form in the dentine tubules during peroxide application and that these small pockets of gas may cause dentine fluid movements that subsequently activate the intradental nerves.⁴³ For example, a number of bleaching products are glycerine-based anhydrous gels that exert a high osmotic force on the tooth tissue. If fluid movements resulting from dentine desiccation initiated bleaching sensitivity, then bleaching sensitivity may therefore be considered a hydrodynamically driven mediated pain. Studies demonstrating mild sensitivity in some patients using placebo bleaching-gels that lack peroxide appear to support this view,²¹ even though the pain intensity in placebo-gel treated patients was lower than in peroxide-exposed subjects.⁴⁴ According to Markowitz³⁹ however there has been no evidence to support this proposed hypothesis. Furthermore,

the presence of an anhydrous vehicle however is not a necessary factor in bleaching sensitivity as bleaching sensitivity has been reported to be a common side effect of treatment with bleaching systems that use glycerine-free peroxide solutions.⁴⁵

BLEACHING SENSITIVITY DURING TOOTH WHITENING

Several investigators have advocated the use of desensitizing products when considering bleaching or whitening teeth since tooth sensitivity was a commonly reported adverse reaction of vital bleaching procedures.^{46,47,48,49} For example the use of a product containing 5% Potassium nitrate or fluoride in a tray prior to, during and following treatment may be beneficial in reducing bleaching sensitivity.^{47,48} In the study by Haywood and colleagues⁴⁷ a Potassium nitrate-fluoride gel applied in the bleaching tray in patients with dentine sensitivity reduced the sensitivity in the majority of the patients and produced some degree of pain relief. However, it is worth mentioning that this study did not include a placebo group in the study design. A further study⁴⁸ reported that the use of an active 3% Potassium nitrate and 0.11 % fluoride desensitizing agent for 30 minutes prior to whitening decreased dentine sensitivity compared to a placebo control. Amorphous calcium phosphate (ACP) can also be used either as a toothpaste or as a professionally applied product.⁵⁰ For patients with pre-existing dentine sensitivity the use of a desensitizing product (toothpaste or in a bleaching tray) prior to bleaching the teeth may alleviate further discomfort during the bleaching phase of the treatment.^{4,47,51} The efficacy of desensitizing agents used in patients who experience dentine sensitivity during tooth whitening has been reported in a study of these patients.⁴⁸

DISCUSSION AND CONCLUSIONS

Tooth whitening procedures using carbamide peroxide solutions/gels greater than 10% have been reported to be associated with increases in dentine sensitivity and gingival irritation. Patients should therefore be informed that they may experience some discomfort when undergoing tooth whitening procedures, although these side effects are generally mild to moderate in nature and in the main a transient problem. Treatment of dentine sensitivity arising from tooth whitening procedures would therefore be based on the severity of the complaint and may involve the provision of a desensitizing tooth paste, gel or varnish or sealant. It is however important for the supervising dental professional to monitor the patient undergoing dentine bleaching procedures and intervene if necessary in a situation where dentine sensitivity may affect the patient's quality of life.

Bleaching sensitivity is generally considered not to be related to exposed root surface or dentine or caries, but rather can be explained by the easy passage of the hydrogen peroxide molecules through the enamel and dentine into the pulp.³⁹ This results in pulpal inflammation affecting the pulpal sen-

sory nerves that are initiated in response to stimuli, such as cold drinks, until the inflammation subsides. However, dentine exposure may be a factor in dentine sensitivity as it is often misdiagnosed as not being clinically present. In fact, other workers²¹ have correlated the incidence and severity of thermal sensitivity with gingival recession and the frequency, not actual duration, of the treatment.^{31,48} It has also been reported that patients who have a pre-existing history of dentine sensitivity or with recession and associated dentine sensitivity may be more likely to experience dentine sensitivity during the bleaching process.²¹ Although there is widely held belief that higher concentrations of bleaching agents produce a greater prevalence of dentine sensitivity, studies reported in the published literature appear to disprove this perception.³¹

Several investigators have advocated the use of desensitizing products when considering bleaching or whitening teeth.^{46,47,48,49,50,51} For example the use of a product containing 5% Potassium nitrate or fluoride in a tray prior to, during and following treatment may be beneficial in reducing bleaching sensitivity.⁴⁶ Amorphous calcium phosphate (ACP) can also be used either as a toothpaste or as a professionally applied product.⁵⁰ ACP however, was used initially for the remineralization of enamel, not dentine. The growth of inorganic hydroxyapatite deposit within the highly organic matrix of dentine is highly questionable.⁵⁰ Even if ACP were to actually promote mineralized formation within the dentine tubules, this process would not be necessarily immediate in nature. The action of ACP on enamel is more of a growth of a hydroxyapatite deposition instead of a rapid occlusion of the dentine tubules in patients with exposed dentine surfaces.⁵⁰ The use of ACP has however not met with wide-spread reports of desensitizing success with tooth whitening procedures.^{50,52}

For patients with pre-existing dentine sensitivity the use of a desensitizing product (toothpaste or in a bleaching tray) prior to bleaching the teeth may alleviate further discomfort during the bleaching phase of the treatment.^{4,47,51} The efficacy of desensitizing agents used in patients who experience dentine sensitivity during tooth whitening has been reported in a study of patients who had pre-existing symptoms prior to the start of the whitening procedure.⁴⁸

CONCLUSIONS

The evidence from the present review would therefore suggest that there may be an association between tooth whitening/bleaching procedures and dentine sensitivity, although most of the earlier published studies on 10% and 15% carbamide peroxide application failed to record whether the subjects had any pre-existing sensitivity prior to the commencement of study and this to some extent may limit one making any definitive conclusion regarding the true extent in terms of prevalence or incidence of dentine sensitivity during the tooth whitening process and whether the incorporation of desensitizers to prevent or reduce dentine sensitivity during and after bleaching is effective. Further research is therefore required

to address this particular problem, and one suggestion would be to use the recommended clinical methodology for evaluating the effectiveness of desensitising toothpastes in reducing or preventing pain from dentine sensitivity in future tooth whitening studies.^{13,53}

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