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(54) Title: METHOD OF SIMULTANEOUSLY CLEANING AND WHITENING TEETH

(57) Abstract: A method for simultaneously cleaning and whitening teeth comprising the steps of: applying a conditioning composition to the teeth surface, applying an oxidizing composition to the teeth surface, applying a sealant composition to the teeth surface, cleaning the teeth surface, polishing the teeth surface and removing the condition compositions from the teeth.

METHOD OF SIMULTANEOUSLY
CLEANING AND WHITENING TEETH

Abstract

[0001] Compositions and methods for whitening the teeth of a patient or subject are described for performing a dental prophylaxis or cleaning procedure during which at least one tooth whitening composition is applied to the surface of a stained tooth, said compositions and methods resulting in a tooth color change that is noticeable to the patient or subject immediately following the procedure. The novel procedure allows for a high degree of tooth whitening to be safely achieved in a short period of time while under the control of a dentist, dental hygienist, or other dental professional, and which at least partially coincides with the performance of a dental prophylaxis or cleaning procedure in order to save significant clinical operator chair time compared to cleaning and whitening procedures that are performed in non-overlapping time frames or appointments.

Background of the Invention

[0002] As the connections between healthy teeth and gums, and general overall health, have become increasingly evident in the past 100 years, oral care has become an important part of people's daily health maintenance regimens. In the process, a healthy looking smile has become representative of one's level of personal grooming and even social status, with straight, white and well shaped teeth being promoted in advertising and by cosmetic dentists as an integral part of one's self-image. Over the past 20 years, the availability of tooth whitening products and services has exploded in the marketplace, ranging from low-priced over-the-counter (OTC) self-applied trays, strips, pens, mouthwashes and toothpastes, to expensive professionally applied or monitored products and procedures capable of effectively whitening teeth in as little as 45 minutes. In general, professionally applied products and services administered to a patient in a dental office or other clinical setting are seen to achieve the best teeth whitening results in the shortest amount of time. This is primarily due to the concentration of active ingredient, usually hydrogen peroxide or a hydrogen peroxide precursor, found in professionally applied whitening compositions. Such high concentrations, typically above 15% hydrogen peroxide by weight and often as high as 50% hydrogen peroxide by weight, can only be safely administered in a controlled setting where a professionally trained individual can isolate soft tissues from contact

with these highly oxidative compositions. Frequent monitoring of a patient's progress over, for instance, a one-hour period is also critical in maintaining a high degree of safety when working with such high hydrogen peroxide concentrations. Optionally, light or heat energy may be applied in conjunction with these strong oxidizing compositions, in order to accelerate the process beyond that which is possible using just the compositions on their own. In general, these professionally-monitored products and services applied in a dental office or clinic will be referred to collectively as in-office or chairside whitening procedures.

[0003] Chairside whitening procedures are generally performed during a dental appointment scheduled specifically for the purpose of whitening the patient's teeth, or as an adjunct following a professional teeth cleaning, formally known as a dental prophylaxis or "prophy". When tooth whitening is conducted immediately following a prophylaxis, the total amount of time that the patient must remain in a dental chair can often exceed two hours.

[0004] A professional tooth cleaning is recommended by the American Dental Association as a means to prevent gum disease. Gum disease, or periodontitis, is the primary cause of tooth loss in adults over the age of 40. Gum disease has also been linked to other health problems, such as heart disease, osteoporosis, respiratory diseases, and other more serious systemic diseases. According to the Center for Disease Control and Prevention, approximately 68% of adults in the United States have at least one professional tooth cleaning annually (2008). There is speculation as to the reasons why so many adults neglect the benefits obtainable from regular tooth cleanings, ranging from lack of health insurance to the fear of dental procedures. Lack of patient knowledge is a problem that can be managed, however studies have shown that better education of patients only leads to modest changes in behavior and attitudes towards preventative dentistry.

[0005] In general, a typical teeth cleaning dental appointment comprises the following procedural steps:

- (1) A dental hygienist or dental assistant may or may not take x-rays of a patient's teeth.
- (2) The dental hygienist or dental assistant will generally take between 15 and 60 minutes to work on the teeth and gums (the exact time depending upon both the amount of accumulation present, as well as the teeth cleaning method chosen), using a variety of tools, including manual or ultrasonic scalers to remove the tartar and plaque from the patient's teeth.

(3) The hygienist will then floss between the teeth and generally complete the cleaning procedure by polishing the front (buccal) and back (lingual) surfaces of the teeth with an abrasive composition known as a prophylaxis (“prophy”) paste. Tooth polishing leaves a smooth tooth surface that is more resistant to the adhesion and buildup of dental plaque between dental cleaning appointments.

[0006] Despite the apparent benefits of preventative teeth cleaning as described above, nearly 80% of the population has some form of gum disease ranging from early stage gingivitis to advanced periodontitis. Symptoms of gum disease may include one or more of the following: bleeding gums, halitosis (bad breath), bad taste in the mouth, tooth sensitivity, sore gums, loose adult teeth, abscessed teeth or gums pulling away from the teeth, changes in the way the teeth fit together or dentures fitting poorly, exudates between the gums and teeth, sores in the mouth, and actual tooth loss. Such a high rate of chronic or acute gum disease indicates a low level of compliance when it comes to scheduling of a regular dental cleaning, and any means of increasing such compliance would clearly be beneficial to the patient’s general oral health.

Brief Description of the Invention

[0007] The inventive tooth cleaning and whitening method comprises novel compositions and procedural steps that allow for the simultaneous performance of a dental prophylaxis and tooth whitening procedure. The procedure involves steps performed at least partially in parallel or contemporaneously with a typical dental prophylaxis procedure during which a significant amount of plaque, tartar and acquired pellicle are removed. In general, these steps may include, but are not limited to, chemical, mechanical and/or chemomechanical tooth surface conditioning, contact or impregnation of one or more teeth with a catalyst, contact or impregnation of one or more teeth with an oxidizing agent, exposure of one or more teeth to actinic energy comprising heat, light, sound, ultrasound, air or mechanical pressure (and combinations thereof), and contact or impregnation of one or more teeth with a tooth remineralizing, opacifying or pigmenting composition. Combinations of the above procedural steps have been developed that accomplish significant whitening of stained teeth in less than about 90 minutes when performed in conjunction with or during a dental prophylaxis procedure.

[0008] The ability of the inventive compositions and methods to simultaneously whiten teeth in parallel with a dental cleaning procedure is highly dependent upon the ability of the oxidizing

agent to penetrate into tooth enamel and dentin. Both tooth enamel and dentin are composite structures comprising both organic and inorganic phases as well as interstitial spaces that are occupied by fluid. These interstitial spaces can accommodate fluid movement, which is generally in an outward direction, in other words from the interior of the tooth towards the enamel surface. However, fluids and other materials in contact with the enamel surface can influence fluid movement through tooth enamel and dentin with concentration gradients and/or capillary action, as well as in conjunction with pressure, heat, light and other external physical forces that can change the dynamic relationship between the tooth and the fluid in contact with the tooth.

[0009] Mathematical models have been constructed to predict the ability of fluids to penetrate into porous substrates. The Lucas-Washburn equation is one such method of developing a comparative “Penetration Coefficient” for various fluids, based on their viscosity, surface tension (with air) and contact angle (with a porous substrate). The model assumes that the porous solid is a bundle of open capillaries, so in other words the Penetration Coefficient is a comparative predictor of capillary flow rate. The Lucas-Washburn equation

$$d^2 = \left(\frac{\gamma \cos \theta}{2\eta} \right) rt$$

predicts the distance (d) traveled by a liquid in a porous substrate, where the liquid has a surface tension (γ) with air, a contact angle (θ) with the porous substrate surface and a dynamic viscosity (η), and where (r) is the capillary pore radius and (t) is the penetration time. The bracketed component of the Lucas-Washburn equation is the Penetration Coefficient, expressed as centimeters per second

$$PC = \frac{\gamma \cos \theta}{2\eta}$$

[0010] The Lucas-Washburn equation predicts that the higher the PC, the faster a liquid will penetrate into a given porous capillary substrate. This means that, at least in theory, a high PC can be achieved for liquids with low viscosities, particularly for compositions also having a low contact angle (which is often, but not always, associated with a liquid having a low surface tension that will lead to efficient wetting of the porous substrate).

[0011] Penetration coefficients have been used recently to design improved dental materials, specifically sealants and low-viscosity composites intended to arrest the progression of carious

lesions (Paris, et al, *Penetration Coefficients of Commercially Available and Experimental Composites Intended to Infiltrate Enamel Carious Lesions*, Dental Materials 23 (2007) 742-748). The authors show that low viscosity materials with high Penetration Coefficients (> 50 cm/s) are capable of penetrating enamel carious lesions better than materials with low PCs (see corresponding patent application US 2006/0264532).

[0012] Prior art tooth whitening compositions have generally been formulated to have high viscosities for better retention in dental trays during the bleaching process, which prevents migration of the whitening composition from the tray due to salivary dilution. Moderate to high viscosities have also been the norm for chairside whitening procedures, in order to prevent the whitening composition from migrating away from the tooth enamel surface. According to the Lucas-Washburn equation, moderate to high viscosity tooth whitening compositions (greater than about 100 centipoise at 25 deg C) will have low Penetration Coefficients and thus be predicted to have restricted movement into the whitening target, that is, the porous enamel substrate. It would thus be advantageous to design a tooth whitening carrier composition comprising an oxidizing agent with a low viscosity (< 100 cps) and a high Penetration Coefficient (> 50 cm/s) in order to achieve rapid penetration into tooth enamel and dentin.

[0013] Other factors affecting the ability of a liquid penetrant to infiltrate enamel and dentin are (1) surface charge effects (which is related to pH of the micro environment within the tooth, as well as the pH and counter ion content of the liquid penetrant), (2) adhesion of the liquid penetrant to the tooth surface (which is related to the surface tension and wetting ability of the liquid penetrant), and (3) osmotic effects (which are related to the direction of diffusion of the interstitial fluid in the tooth structure in relation to the liquid penetrant in contact with the tooth).

[0014] In general, the inventive simultaneous tooth cleaning and whitening method comprises the following steps:

- 1) Application of an oxidizing composition to the surfaces of the teeth to be whitened;
- 2) Performing a dental cleaning or hygiene procedure while the oxidizing composition is in contact with the teeth to be whitened.

[0015] There is typically an extensive amount of scraping, scaling, and other modes of plaque and tartar removal performed during a dental cleaning or prophylaxis. During the cleaning

procedure, the patient's mouth is usually open for an extended period of time during which excess saliva may accumulate in the oral cavity and come in contact with the tooth surfaces. Also, the patient is typically asked to rinse with water or a mouthwash at various times during the cleaning procedure in order to clear debris (plaque, tartar, blood, saliva, etc) from the oral cavity that accumulates from the cleaning process. It has been found that in order to achieve a desirable (that is, a noticeable) level of tooth whitening during said dental cleaning or prophylaxis, it is advantageous to prevent moisture from saliva or external sources (such as the rinsing solutions referred to above) from directly contacting the tooth surfaces that have been previously contacted with the oxidizing composition. By creating a barrier between extraneous moisture and the oxidizing composition, said moisture is prevented or limited in its ability to remove, dilute, neutralize or otherwise decrease the effectiveness of the oxidizing composition during the cleaning procedure.

[0016] One means of limiting the contact of external moisture with the oxidizing composition is to utilize an oxidizing composition having hydrophobic ("water-repelling") properties when in contact with the tooth surface.

[0017] An alternative means of preventing moisture contamination of the oxidizing composition on the tooth surface is to cover the oxidizing composition with a film of water-insoluble or water-resistance material. Such materials may include, but are not limited to, polymer films and water-resistant or water-insoluble fluids, gels, creams, waxes and solids.

[0018] Yet another alternative means of preventing moisture contamination of the oxidizing composition on the tooth surface is to cover the oxidizing composition with a curable composition that can be converted from a liquid or gel into a higher viscosity liquid, gel or solid upon exposure to an external source of energy. Said external energy source may be electromagnetic or light energy, sound or ultrasound energy, mechanical or vibrational energy, electrical energy, or combinations thereof.

[0019] A preferred tooth cleaning and whitening method comprises the following steps

- 1) Placing a cheek and lip retraction means into the oral cavity of a subject. Said means may include a cheek retractor and/or cotton rolls placed in such a way as to prevent the soft

tissue of the inside of the lips and cheeks from coming into contact with the tooth surfaces.

- 2) Conditioning of the teeth surfaces to be whitened with a conditioning agent or conditioning composition, using chemical, mechanical, or chemo-mechanical means.
- 3) Contacting the conditioned tooth surfaces with one or more compositions comprising an oxidizing agent.
- 4) Contacting the tooth surfaces with a water-resistant coating or film-forming composition to protect the oxidizing agent from direct contact with external moisture during the tooth cleaning process.
- 5) Cleaning and scaling of subject's teeth in proximity to the gum line, gingival margins and crevicular spaces while the compositions of steps (3) and (4) above are in contact with the tooth surfaces
- 6) Polishing the teeth with prophylaxis or polishing paste following completion of step (5)
- 7) Optionally repeating steps (3) and (4)
- 8) Cleaning and rinsing all residual materials from tooth and gum surfaces that were applied or produced during the performance of steps (1) through (7)

[0020] Modifications to the above procedure are possible and are some cases preferable. For instance, the conditioning agent or conditioning composition may be combined with the oxidizing composition of step (3) in order to reduce the amount of time required to perform the combined cleaning and whitening procedure. Also, water-resistant properties may be imparted to the oxidizing composition of step (3) in order to obviate the need for a separate step (4). Therefore, it is contemplated, but not required, that the compositions and/or agents of steps (2), (3) and (4) may be combined into a single composition (a) prior to packaging, (b) just prior to use, or (c) on the tooth surface during use. Optionally, a tooth-desensitizing agent, such as potassium nitrate, may be applied before, during, or after any of the steps outlined above. Such tooth-desensitizing agent may be applied as a stand-alone formulation or combined with the conditioning agent, oxidizing agent, water-resistant or film-forming composition, or any combination of these.

Detailed Description of the Invention

[0021] The compositions of the present invention are designed to provide a fast and effective means of whitening the teeth during the performance of a dental cleaning or prophylaxis. Various combinations of tooth conditioning compositions, oxidizing compositions and sealant

compositions are envisaged to have utility in the practice of the inventive method, and the properties of these individual compositions may be combined into a single composition for ease of use and application. Alternatively, a tooth conditioning function may be combined with an oxidizing function into a single composition. Another alternative is to combine a tooth sealing function with an oxidizing function to reduce the number of application steps.

[0022] The tooth conditioning composition may comprise a fluid carrier and one or more tooth conditioning ingredients. Fluid carriers include water, ethanol, diethyl ether, methoxypropane (methyl propyl ether), dimethyl isosorbide and combinations thereof. The tooth conditioning function, that is the ingredient or ingredients that remove the acquired pellicle and subsequently open the enamel porosities for better penetration of the oxidizing composition, may be provided by ingredients having an acidic and/or calcium chelating capabilities. Useful acidic compounds include both inorganic and organic acids such as phosphoric acid, hydrochloric acid, acetic acid, lactic acid, citric acid, and their salts. Useful calcium chelating compounds include both inorganic and organic chelating agents such as ethylenediaminetetraacetic acid (EDTA), phytic acid, 1-hydroxyethylidene-1,1'-diphosphonic acid, citric acid, and their salts. The tooth conditioning composition may also comprise a colorants and/or pigments to assist in the placement and application of the tooth conditioning composition onto the teeth during the combination whitening and cleaning procedure.

[0023] The oxidizing composition comprises a fluid carrier and an oxidizing agent. Fluid carriers include water, ethanol, diethyl ether, methoxypropane (methyl propyl ether), dimethyl isosorbide and combinations thereof. Oxidizing agents include peroxides, metal chlorites, percarbonates, perborates, peroxyacids, hypochlorites and combinations thereof. Preferred oxidizing agents are hydrogen peroxide, carbamide peroxide, poly (vinyl pyrrolidone)-hydrogen peroxide complex (Peroxydone®, ISP Corp, Wayne, NJ), peroxyacetic acid, and sodium chlorite. The oxidizing composition preferably has a viscosity of less than about 100 centipoise and most preferably less than about 10 centipoise. The oxidizing composition may also comprise active components further related to the tooth whitening function (such as stabilizers, a secondary oxidizing agent, an oxidation catalyst, a pH-adjusting agent, and a calcium chelating agent), or to a non-tooth whitening function (such as remineralization of the tooth surface, prevention of tooth decay, tooth desensitivation, prevention of gingivitis and/or periodontal disease, and other diseases or conditions of the oral cavity). In addition, the oxidizing composition may comprise one or more colorants and/or pigments to assist in the placement and application of the sealant onto the teeth

during the combination whitening and cleaning procedure. Such colorants and/or pigments may also be present to provide a stain masking effect that changes the appearance of the tooth while the oxidizing composition is in contact with the tooth surface during the procedure.

[0024] Preferred oxidation catalysts are chelated metal complexes, in particular complexes of iron and manganese. Particularly preferred chelated metal complexes are the family of tetraamido-N-macrocyclic ligand (TAML) iron catalysts described in US Patents 7,060,818, 6,241,779, 6,136,223, 6,100,394, 6,054,580, 6,099,586, 6,051,704, 6,011,152, 5,876,625, 5,853,428, and 5,847,120.

[0025] The oxidizing compositions of the present invention may also contain a surface active agent in order to lower the surface tension of the composition to provide for better wetting and adhesion of the liquid to the surface of the tooth. Anionic, cationic, non-ionic and zwitterionic surfactants are contemplated to have utility in providing the oxidizing compositions with a low surface tension. Preferred surfactants are sulfobetaines (such as amidosulfobetaine 3-16 and Lonzaine CS) and fluorosurfactants (such as Capstone 50 and Capstone FS-10).

[0026] Sealant compositions of the present invention may comprise a water-resistant polymer, copolymer or crosspolymer, and a fluid carrier. Hereinafter the term "polymer" and "polymers" shall be used to denote polymer(s), copolymer(s) or crosspolymer(s). Suitable water-resistant polymers include acrylate polymers, methacrylate polymers, modified cellulosic polymers, silicone polymers, urethane polymers, polyamide polymers, vinyl polymers, vinyl pyrrolidone polymers, maleic acid or itaconic acid polymers, and others. The water-resistant polymer should be soluble or dispersible in the fluid carrier. Particularly preferred polymers are poly (butyl methacrylate-co-(2- dimethylaminoethyl) methacrylate-co-methyl methacrylate), poly (ethyl acrylate-co-methyl methacrylate-co-trimethylammonioethyl methacrylate chloride), ethylcellulose, and esterified or crosslinked poly (methyl vinyl ether-co-maleic anhydride). The fluid carrier may be a volatile solvent which will evaporate after contacting the sealant composition with the tooth surface, leaving behind a liquid or solid coating or film. Said solvent should have an evaporation rate equal to or greater than that of water, and preferably equal to or greater than that of butyl acetate. Suitable solvents include, but are not limited to, water, ethanol, diethyl ether, methoxypropane (methyl propyl ether), acetone, ethyl acetate, and other highly volatile solvents.

[0027] Alternatively, the sealant compositions may be curable liquids or gels, which are placed on the tooth surface and subsequently exposed to some form of activating energy which converts the liquid or gel sealant composition to a solid coating or film. Curable sealant compositions may also be chemically cured, whereby two or more components are combined just prior to use and placed on the tooth surface to cure, in other words, to change from a liquid or gel into a solid coating or film.

[0028] The sealant composition may also comprise active components related to a tooth whitening function (such as an oxidizing agent, an oxidation catalyst, a pH-adjusting agent, and a calcium chelating agent), or to a non-tooth whitening function (such as remineralization of the tooth surface, tooth desensitivation, prevention of tooth decay, prevention of gingivitis and/or periodontal disease, and other diseases or conditions of the oral cavity). In addition, the sealant composition may comprise one or more colorants and/or pigments to assist in the placement and application of the sealant onto the teeth during the combination whitening and cleaning procedure. Such colorants and/or pigments may also be present to provide a stain masking effect that changes the appearance of the tooth while the sealant composition is attached to the tooth surface in the form of a coating or film.

[0029] The combination whitening and cleaning method described herein may also be practiced by employing an additional source of energy to accelerate the oxidation process and further reduce the time needed to complete the procedure. External energy sources such as electromagnetic or light energy, sound or ultrasound energy, mechanical or vibrational energy, electrical energy, or combinations thereof may be advantageously employed at any point in time during the combination whitening and cleaning procedure to accelerate the process.

[0030] Examples

[0031] In order to achieve a significant degree of tooth whitening in an abbreviated time frame suitable for integration into the tooth cleaning (dental prophylaxis) process, ideal conditions for (1) oxidizer penetration into the tooth and (2) conversion of initial oxidizer form into active whitening species must be facilitated.

[0032] Time limitations are imposed on the additional steps required to achieve whitening during the tooth cleaning process by the realities of patient scheduling in the typical dental office, and

such additional steps should not exceed 30 minutes beyond or in addition to the time required to perform a typical dental prophylaxis. Optimal conditions for penetration of an active whitening composition into tooth enamel must be present in order to reduce the amount of time and oxidizer concentration required to reach intrinsic stain depth. Important factors related to oxidizer penetration into the tooth are (1) the viscosity of the oxidizing composition, (2) the surface tension of the oxidizing composition and (3) the surface free energy (also called the critical surface tension) of the tooth surface.

[0033] The surface free energy of exposed tooth enamel is generally in the range of about 50 – 55 dynes/cm, however the acquired pellicle can lower this number significantly. In fact, one of the important functions of the acquired pellicle is to reduce the critical surface tension of the tooth surface in order to reduce the adhesion of bacteria. Liquid and gel compositions contacting the tooth surface penetrate into the tooth structure in relation to four primary factors: time, viscosity of the liquid or gel, surface tension of the liquid or gel, and surface free energy of the tooth at the point of contact.

[0034] The relationship of liquid surface tension to solid surface free energy, low contact angle (the tangential angle formed by a droplet deposited on a solid surface) and low viscosity, are all directly related to the Penetration Coefficient (as derived from the Lucas-Washburn equation) and must be optimized for the whitening composition to (1) rapidly wet the surface of tooth enamel and (2) penetrate the available porosities and channels through enamel as quickly as physically possible.

[0035] Example 1

[0036] The ability of various oxidizing compositions to penetrate intact enamel and dentin was determined as follows. Extracted molar and pre-molar teeth were obtained from orthodontists with patient consent and stored refrigerated in phosphate buffered saline (PBS) solution at pH 6.8 until use. In order to assess the ability of various liquid carrier fluids to penetrate tooth enamel, teeth were sectioned to remove their roots and a 3mm diameter chamber was created in the center of the sectioned crown that was filled with PBS solution. The crowns were partially immersed (chamber with PBS solution facing up) in various liquid carrier fluids and a small (1 microliter) sample of the PBS solution was drawn every 60 seconds and placed on a peroxide test strip (EM Quant Strips 10337, EMD Chemicals, a division of Merck SA, Darmstadt, Germany) to

determine the amount of time required for hydrogen peroxide to penetrate the tooth enamel and dentin from the outer surface of the crown to the interior chamber containing PBS.

[0037] Oxidizing compositions in Table 1 below were prepared and stored in 20 ml glass vials until use.

Table 1

Ingredient	Percent (w/w)											
	1A	1B	1C	1D	1E	1F	1G	1H	1I	1J	1K	1L
Water	75.0	65.0	75.0	65.0	85.0	75.0	65.0	75.0	65.0	75.0	65.0	100.0
Ethanol 200	10.0	20.0	5.0	15.0		5.0	15.0					
Diethyl ether			5.0	5.0								
Methoxypropane						5.0	5.0					
Acetone								10.0	20.0			
Dimethyl isosorbide										10.0	20.0	
Hydrogen peroxide	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	0.0
	Adjusted to pH 4.0 with potassium hydroxide 0.1M											
Viscosity (cps @ 25C)	<1	<1	<1	<1	1.3	<1	<1	<1	<1	1.5	1.5	1
Surface tension (dynes/cm ²)	<40	<40	<40	<40	>50	<40	<40	<40	<40	<40	<40	>50
Contact angle (deg)	<10	<10	<10	<10	30+	<10	<10	<10	<10	15	15	50+
PC (calculated)	>100	>100	>100	>100	<50	>100	>100	>100	>100	>100	>100	<30
H ₂ O ₂ detection (min)	13	12	12	10	20	14	12	14	14	15	15	ND*

* ND = Not detected

[0038] Oxidizing compositions in Table 1 trended towards faster penetration of the tooth when both contact angle and viscosity of the composition was low (Examples 1A, 1B, 1C, 1D, 1F, 1G, 1H, 1I, 1J, and 1K). Oxidizing with high contact angles (greater than 30 degrees) did not seem to penetrate as well as those with contact angles less than about 10 degrees.

[0039] Example 2

[0040] The following multi-step process was developed to provide for rapid and effective whitening of the teeth during a dental cleaning procedure.

[0041] Step 1 – Acquired Pellicle Removal

[0042] Facilitating oxidizer penetration into the tooth requires a thorough removal or modification of the acquired pellicle prior to contact with the oxidizer formulation. Therefore, whether integrated into a dental prophylaxis procedure or performed as a stand-alone process, the first step in the abbreviated whitening process (after determining a starting tooth shade) must be the removal of the acquired pellicle using chemical, mechanical or (preferably) chemo-mechanical means. Once the acquired pellicle has been removed, it is important that the “cleaned” tooth enamel surface has limited contact with the patient’s saliva prior to application of the oxidizer composition (see Step 2) in order to prevent reformation of the pellicle film on the exposed enamel surface. Removal or modification of the acquired pellicle and optional micro-roughening of the exposed enamel surface will elevate the enamel surface free energy (preferably above about 60 dyne/cm), which promotes better wetting of the enamel surface by the oxidizing composition. Surface wetting is a key factor related to the speed at which a composition penetrates enamel, analogous to the effects of viscosity and surface tension on the penetration of bonding adhesives into conditioned enamel and sealants into caries lesions.

[0043] Step 1a Placement of cheek retractor or other means of preventing contact of the lips and interior gum surfaces with the teeth

[0044] Step 1b Application of Conditioner for 30 - 60 seconds

[0045] Tooth Conditioner Composition

Ingredient	Percent (w/w)
Water	90.0
Poly (methyl vinyl ether-co-maleic anhydride)*	10.0

*Gantrez S-95 (ISP Corp, Wayne, NJ) (hydrolyzed, pH 2.0)

[0046] Step 2 – Oxidizer Contact and Penetration

[0047] Once the acquired pellicle has been removed, the teeth surfaces are contacted with a low viscosity oxidizer composition with a surface tension significantly lower than that of the surface free energy of the exposed enamel surface. A low viscosity oxidizing composition that has a low surface tension will have a very low contact angle when placed on the enamel surface and thus be better suited to penetrate into the enamel porosities. The oxidizer composition should comprise hydrogen peroxide in an aqueous form (or mixed with viscosity-reducing solvents) and at a concentration between about 1% and 30% by weight (higher amounts being contemplated in situations where precise control and placement of the oxidizing composition is possible). The oxidizing composition should also have a pH within a range similar to that reported for the isoelectric point of tooth enamel, which is between about 3.8 and 4.7, although higher pH levels are possible with oxidizing compositions comprising ionized species capable of counteracting the influence of charged components in tooth enamel. The oxidizing composition is brushed repeatedly onto the tooth surfaces to be whitened over the period of about 7 – 10 minutes to provide as much full strength hydrogen peroxide at the interface over the initial treatment phase.

[0048] Step 2a Application of oxidizing composition to buccal and (optionally) lingual surfaces of teeth

[0049] Oxidizer Composition

[0050] Example 1D

[0051] Step 3 – Sealing Enamel Surface Prior to Dental Prophylaxis Procedure

[0052] In order to prevent dilution or removal of the oxidizing composition in or from the tooth enamel treated in accordance with Step 2 above, a water-resistant protective sealant is applied (and if solvent-based, allowed sufficient time for the carrier solvent to evaporate). The sealant composition may also comprise an additional oxidizing agent to provide an additional reservoir of whitening active, and/or an advanced oxidation catalyst in order to promote active oxidizing species such as hydroxyl radicals ($\bullet\text{OH}$) and perhydroxyl anions ($-\text{OOH}$).and/or a desensitizing agent to reduce or eliminate any tooth sensitivity associated with the procedure.

[0053] Step 3a Application of Sealant to buccal and (optionally) lingual surfaces of teeth

[0054] Sealant Composition

Ingredient	Percent (w/w)
Ethanol 200 proof	90.0
Poly (butyl methacrylate-co-(2- dimethylaminoethyl) methacrylate-co-methyl methacrylate)*	10.0

*Eudragit E100 or EPO (Evonik Rohm GmbH, Darmstadt, Germany)

[0055] The sealant composition is applied onto the surfaces of the teeth previously contacted with the oxidizing composition and allowed to fully dry before proceeding to Step 4.

[0056] Step 4 – Performance of the Dental Prophylaxis Procedure

[0057] Following the sealing process, a dental prophylaxis is performed using standard protocols and materials. Care should be taken to avoid excessive disruption of the sealant on the buccal and lingual (if coated) surfaces of the teeth during the cleaning procedure. The dental prophylaxis is otherwise performed in a standard fashion, including polishing of the teeth with a standard prophy paste (which will remove the Sealant applied in Step 3). A final tooth shade may be taken at this time.

[0058] Step 5 – Final Treatment

[0059] If time permits, Steps 2 and 3 are repeated after prophy cleanup. No further intervention is required to remove the Sealant if applied after completion of the dental prophylaxis and dismissal of the patient. The Sealant may remain in place after the patient leaves the office and will slowly erode over time. The patient may also be supplied with a home-use version of the oxidizing composition and the sealant as an option for continued improvement in tooth color.

[0060] The above steps were performed on extracted molars and premolars (n = 25) obtained through orthodontists with patient consent and stored refrigerated in phosphate buffered saline (PBS) solution at pH 6.8 until use. Individual teeth were removed from the PBS solution, allowed to air dry for 60 seconds and the roots inserted up to the cemento-enamel junction into a high viscosity aqueous gel to keep the roots hydrated during the procedure. An initial tooth shade was taken using a Minolta CM504i chromameter (Konica-Minolta) and recorded. Steps 2 (total treatment time of 10 minutes) and 3 (total treatment time of 120 seconds) were performed on the

extracted teeth, and a 32 minute period was allowed to elapse during which the teeth were rinse with water every 8 minutes to simulate the rinsing process that typically occurs during the cleaning process. After the simulated cleaning process time had elapsed, the teeth were polished with a medium grit prophylaxis paste using a slow speed handpiece and prophylaxis cup. Teeth were rinse with water and a final tooth shade was taken using the method described above and recorded in Table 2 below (L, a, b = Initial color readings, L*, a*, b* = final color readings).

Table 2

Tooth	L	a	b	L*	a*	b*	Delta L	Delta a	Delta b	Delta E
1	76.10	3.14	15.98	78.11	1.61	13.13	2.01	-1.53	-2.85	3.81
2	76.90	3.44	12.45	80.98	2.40	13.01	4.08	-1.04	0.56	4.25
3	74.23	3.32	16.05	78.33	1.98	12.77	4.10	-1.34	-3.28	5.42
4	74.25	2.00	16.21	77.21	1.74	12.12	2.96	-0.26	-4.09	5.06
5	78.21	3.24	14.76	80.43	1.99	11.26	2.22	-1.25	-3.50	4.33
6	75.21	3.01	15.90	77.77	2.45	14.01	2.56	-0.56	-1.89	3.23
7	74.79	1.82	13.88	78.23	1.43	13.20	3.44	-0.39	-0.68	3.53
8	72.24	3.32	16.43	75.20	2.99	13.95	2.96	-0.33	-2.48	3.88
9	73.19	3.87	15.81	78.81	2.33	10.32	5.62	-1.54	-5.49	8.01
10	77.31	3.66	14.73	77.60	1.84	9.99	0.29	-1.82	-4.74	5.09
11	71.89	3.97	17.68	76.39	2.77	14.02	4.50	-1.20	-3.66	5.92
12	74.54	3.58	14.32	78.40	2.87	13.13	3.86	-0.71	-1.19	4.10
13	73.29	3.82	14.65	78.41	2.02	13.03	5.12	-1.80	-1.62	5.66
14	74.03	3.92	16.33	76.75	2.36	14.56	2.72	-1.56	-1.77	3.60
15	71.99	2.98	15.03	77.90	1.75	11.82	5.91	-1.23	-3.21	6.84
16	73.98	3.92	15.57	78.02	1.99	11.08	4.04	-1.93	-4.49	6.34
17	73.12	3.22	16.23	76.19	1.56	13.84	3.07	-1.66	-2.39	4.23
18	76.00	3.42	15.48	78.88	1.98	10.63	2.88	-1.44	-4.85	5.82
19	73.94	3.73	14.14	78.58	2.02	10.73	4.64	-1.71	-3.41	6.01
20	74.74	3.46	15.02	77.33	2.38	13.05	2.59	-1.08	-1.97	3.43
21	70.95	3.98	17.43	75.02	2.97	12.83	4.07	-1.01	-4.60	6.22
22	73.49	4.03	16.55	77.91	3.13	13.43	4.42	-0.90	-3.12	5.48
23	76.03	3.10	18.30	78.73	1.57	13.22	2.70	-1.53	-5.08	5.95
24	73.83	3.28	17.43	77.00	1.22	10.15	3.17	-2.06	-7.28	8.20
25	74.17	2.98	15.12	78.36	2.09	11.03	4.19	-0.89	-4.09	5.92
Average	73.84	3.46	16.03	77.63	2.06	11.98	3.79	-1.40	-4.04	5.72

Claims

1. A method for simultaneously cleaning and whitening teeth comprising the steps of:
applying a conditioning composition to the teeth surface;
applying an oxidizing composition to said teeth surface;
applying a sealant composition to said teeth surface;
cleaning said teeth surface;
polishing said teeth surface; and
removing said condition composition, said oxidizing composition and said sealant composition.
2. A method for simultaneously cleaning and whitening teeth comprising the steps of:
applying a composition to the teeth surface;
wherein said composition is comprised of at least a fluid carrier, a tooth conditioner, an oxidizing agent and a water-resistant polymer.
cleaning said teeth surface;
polishing said teeth surface; and
removing said composition.
3. The method of claim 1 wherein said conditioning composition is comprised of a fluid carrier and at least one tooth conditioner.
5. The method of claims 2 and 3 wherein said tooth conditioner is comprised from the group consisting of phosphoric acid, hydrochloric acid, acetic acid, lactic acid, citric acid, EDTA, phytic acid, 1-hydroxyethylidene-1,1'-diphosphonic acid and combinations thereof.
6. The method of claim 1 wherein said oxidizing composition is comprised of a fluid carrier and at least one oxidizing agent.
7. The method of claims 2 and 6 wherein said oxidizing agent is comprised from the group consisting of peroxides, metal chlorites, percarbonates, perborates, perxyacids, hypochlorites and combinations thereof.
8. The method of claims 3 and 6 wherein said fluid carrier is comprised from the group consisting of water, ethanol, diethyl ether, methoxypropane, dimethyl isosorbide and combinations thereof.
9. The method of claim 1 wherein said sealant composition is comprised of a fluid carrier and at least one water resistant polymer.
10. The method of claims 2 and 9 wherein said fluid carrier has an evaporation rate equal to or greater than water.
11. The method of claims 2 and 9 wherein said water resistant polymer is comprised from the group consisting of acrylate polymers, methacrylate polymers, modified cellulosic polymers,

silicone polymers, urethane polymers, polyamide polymers, vinyl polymers, vinyl pyrrolidone polymers, maleic anhydride, itaconic acid polymers and combinations thereof.

12. The method of claim 1 wherein said sealant composition is curable.
13. The method of claims 1 and 2 further comprising the step of applying an external energy source.
14. The method of claim 13 wherein said external energy source is comprised of the group consisting of electromagnetic, light, sound, ultrasound, mechanical, vibration, electrical or combinations thereof.