Assessment of the effect of Remin Pro remineralizing agent on the microhardness of bleached enamel

Thesis

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Dedication

I wish to dedicate this work to

My great parents and brothers, whom I could have never done this without their support, encouragement and sacrifices. Thank you for teaching me to believe in myself, in God and in my dreams.

My lovely friends and colleagues.

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3D	Three dimensional
AAS	Atomic absorption spectroscopy.
ACP	Amorphous calcium phosphate
AFM	Atomic force microscopy
APF	Acidulated phosphate
Ca	Calcium
CO_2	Carbon dioxide
CP	Carbamide peroxide
CPP	Casein-phosphopeptide
CPP-ACP	Casein-phosphopeptide-amorphous calcium phosphate
CPP-ACPF	Casein-phosphopeptide amorphous calcium phosphate fluoride
DCPD	Dicalcium phosphate-dihydrate
Fe(II)	Ferrous ion
Ft- Raman	Fourier transform spectroscopy.
H_2O_2	Hydrogen peroxide
HA	Hydroxyapatite
HP	Hydrogen peroxide
HV	Vicker's hardness number.

LDF	Laser Doppler Flowmetry
NaF	Sodium fluoride
n-HA	Nano-hydroxyapatite
nm	Nanometer
OTC	Over-the-counter
P	Phosphorous
P11-4	Oligopeptide-104 (Self-assembling peptide)
Ppm	Part per million
SEM	Scanning Electron Microscope
TCP	Tricalcium phosphate
TMP	Trimetaphosphate
β-TCP	Beta-tricalcium phosphate

Bleaching, although not new to dentistry, has gained much popularity in the recent years due to the increase of the esthetic demands of patients. It is considered to be one of the most conservative methods to treat tooth discoloration if compared to other procedures such as veneers and partial or full coverage crowns.[1,2] There are 3 main bleaching techniques that are commonly used nowadays; in-office bleaching, home bleaching, which is usually dentist-supervised, and mass market bleaching products.[3,4] Bleaching agents used in these techniques contain different concentrations of either hydrogen peroxide (HP) or carbamide peroxide (CP).[5] Home bleaching agents typically contain lower concentrations of HP or CP than in-office bleaching agents. Peroxides can easily penetrate the hard dental tissues and work by reacting with the organic materials within the hard tooth structure that contain pigments or stains resulting in significant whitening of teeth.[6]

Unfortunately, since the mechanism of bleaching involves the reaction of free radicals produced from peroxides in the bleaching agents with the organic content of enamel, some degree of deterioration to the enamel matrix takes place. This deterioration can be accompanied by the loss of some inorganic crystals that are bound to the organic matrix (demineralization) resulting in roughness, decreased hardness of enamel surface and tooth hypersensitivity.[7] Another possible cause of demineralization upon bleaching is the low pH value of most bleaching agents, some of them even had pH values of less than 5.5, which is the critical value for the demineralization of enamel.[8]

In order to decrease the adverse effects of demineralization that happen upon bleaching, various remineralizing regimens are recommended

after the bleaching procedure to promote remineralization and decrease tooth sensitivity.[9-11] These regimens are supplied in different forms such as: mouthwashes, toothpastes, dentrifices, gels, solutions or varnishes. Remineralizing agents that are most commonly used include fluorides and calcium-phosphate based systems such as casein phosphopeptide-amorphous calcium phosphate (CPP-ACP), which is known as recaldent, with or without fluoride (MI paste plus and MI paste), beta-tricalcium phosphate (clinpro tooth crème) and bioactive glass (Novamin).[12-14] Products that combine hydroxyapatite which is the main mineral content of enamel, xylitol, which has an antibacterial action, and fluoride are also available (Remin Pro).[15]

Therefore, the study of the effect of remineralizing agent on microhardness of bleached enamel might be of value.

I. Background

Bleaching has become one of the most popular techniques used in esthetic dentistry to treat and whiten tooth discoloration.[16] It is considered very conservative in comparison to other modalities used to treat discoloration, such as composite/ceramic veneers, crowns and composite restorations, since it doesn't involve the loss of any tooth structure.[1] Tooth discoloration can be intrinsic, extrinsic or a combination of the two. Intrinsic discoloration can occur before or after tooth eruption by the incorporation of chromatogenic materials into enamel and dentin, as those caused by the administration of tetracycline, fluorosis, trauma, pulp necrosis and aging. While extrinsic discoloration occurs due to consumption of foods and drinks containing stains such as coffee, tea, spices or tobacco. Most extrinsic stains can be treated by scaling and polishing, while intrinsic stains and the more stubborn extrinsic stains require bleaching. Bleaching can be performed externally for vital teeth or internally for endodontically treated teeth.[17,18] However, in some cases of intense intrinsic discolorations such as pitting fluorosis and opaque fluorosis, both bleaching and crown or veneer construction can be used to treat the discoloration and obtain a uniform tooth shade.[19]

Tetracycline-stained teeth are very resistant to bleaching and may require periods of 2-12 month of daily home-bleaching in combination with occasional booster in-office bleaching sessions using high concentrations of hydrogen peroxide (about 35%). The discoloration may not be removed completely and teeth may retain a greyish undertone especially in cervical third where the enamel is very thin and the discolored dentine may show through it.[20,21]

II. Mechanism of whitening (bleaching chemistry)

Bleaching is "the chemical degradation of chromogens".[18] The active ingredient in most bleaching agents is hydrogen peroxide or carbamide (urea) peroxide which reacts with water releasing hydrogen peroxide. Urea in carbamide peroxide is thought to dissociate into CO_2 and ammonia which increase the pH and ease the bleaching procedure. In basic media, lower activation energy is required to produce free radicals from hydrogen peroxide. Hydrogen peroxide can easily diffuse through the organic matrix of the tooth due to its low molecular weight to react with the discolored particles (chromogens). Hydrogen peroxide is a strong oxidizing agent that produces free radicals, reactive oxygen molecules and hydrogen peroxide anions. Perhydroxide free radical ($HO^{\bullet}_2$) is the most effective in tooth bleaching but requires an alkaline pH and trace metal catalysts to be formed.[2,18]

The breakdown of hydrogen peroxide into free radicals:

$H_2O_2 \rightarrow 2HO^{\bullet}$ (hydroxyl radical)

$HO^{\bullet} + H_2O_2 \rightarrow H_2O + HO^{\bullet}_2$ (perhydroxyl radical)

$HO^{\bullet}_2 \leftrightarrow H^+ + O^{\bullet}_2$ (superoxide anion)

Hydrogen peroxide forms free radicals like hydroxyl and perhydroxyl radicals and superoxide anions.

$2H_2O_2 \leftrightarrow 2H_2O + 2\{O\} \leftrightarrow 2H_2O + O_2$

Reactive oxygen molecules, those are unstable and transformed to oxygen.

$H_2O_2 \leftrightarrow H^+ + HOO^-$ (Hydrogen peroxide anions)[22]

Chromogens can be either organic or inorganic. Organic chromogens contain unsaturated double bonds in their chemical structure. (Figure 1A). Hydrogen peroxide acts by oxidizing these double bonds within the discolored compound through its free radicals, thus breaking it down into smaller molecules that diffuse outside of the tooth or changing its absorption energy causing the whitening effect. (Figure 1B). On the other hand, inorganic chromogens are a lot more difficult to bleach as they are locked within the crystal lattice of enamel. For proper bleaching in this case, using catalysts such as Fe(II) is required to oxidize the sulfide or thiolate bond before application of the bleaching agent. The lack of such catalysts causes extended treatment time in these cases. Other bleaching products may contain sodium hypochlorite (NaOCl) that has a similar oxidizing effect to that of hydrogen peroxide. (Figure 1C).[18]

Bleaching by either hydrogen or carbamide peroxide requires dry, clean, debris-free teeth as the salivary enzymes and proteins can catalyse the non-bleaching breakdown of peroxides into water and oxygen making it ineffective.[22]