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A Comparison of Color Improvement of NovaMin, Casein Phosphopeptide-Amorphous Calcium Phosphate and Arginine Treatments Applied to Artificial White Spot Lesions

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ABSTRACT

Aims: To determine the most effective treatment method for esthetic improvement of demineralized white spot lesions (WSL) of three treatments by using colorimeter.

Methods and Materials: An in vitro study was done on 30 recently extracted impacted third molars, to compare the color improvement of artificial WSL after treatment with three approaches by using colorimeter device, all samples were immersed in solutions of pH cycle for 10 days (demineralizing solution for 3hours, remineralizing solution for 20 hours and artificial saliva for 30 minutes twice daily. Then the sample divided randomly into 3 groups. Group1: NovaMin, group2: CPP ACP (Casein phosphopeptide amorphous calcium phosphate) and group3: Arginine containing toothpastes. Measurements were obtained in an adequately lit, windowless room with ambient temperature (19-25) ºC using colorimeter. An ANOVA was constructed (value P≤ 0.05).Followed by Duncan's post–hoc test for comparisons of mean values. Results: There were significant differences among the various groups with respect to color changes means values of samples. The lowest value was for Arginine group and highest value was for Novamin group containing toothpastes.

Conclusion: Sensodyne tooth paste (containing Novamin) is more effective in color improvement of artificial WSLs when compared with GC (containing CPP-ACP) and Colgate (containing Arginine) tooth paste.

Keywords: Colgate, CPP-ACP, Demineralization, Novamin, PH cycle

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INTRODUCTION

WSLs are defined as "subsurface enamel porosity from carious demineralization, and the enamel lesions that look chalky white and opaque [1-5]. One of the main goals of orthodontic therapy is aesthetics. The development of WSLs, which are mostly brought on by poor oral hygiene maintenance, is one of the detrimental outcomes of orthodontic therapy. At least 50% of patients with fixed appliances had at least one WSL [6-9]. Mineral loss in the surface or subsurface enamel is what causes the white look, which is the result of optical phenomena. Subsurface demineralization, which produces holes between the enamel rods, is the first step in the disintegration of enamel crystals. As a result of surface roughness, loss of surface shine, and changes in internal reflection, the RI in the affected region is altered, which increases visual enamel opacity since porous enamel scatters more light than sound enamel. As spontaneous remineralization through saliva, which involves mineral gain in the surface layer of WSLs, has minimal effect on the esthetic and structural qualities of the deeper lesions, these WSLs can persist for up to 5–12 years. Remineralizing agents must be used topically to the tooth surface following debonding in order to heal the deeper section of the WSLs for improved aesthetics and structural strength [10]. New remineralizing mechanisms would be required to accomplish more significant lesion regression since saliva has the capacity to demineralize, but the amount of remineralization generated by saliva is limited and only happens on the surface layer of the lesion [11].

NovaMin, also known as calcium sodium phosphosilicate, is composed of body-produced minerals and bioactive glass. It is powdered, colorless, and very biocompatible. In order to create hydroxycarbonate apatite crystals

that are comparable to the hydroxyapatite crystals that make up the mineral composition of enamel, NovaMin reacts with liquids like water and saliva, releasing calcium, sodium, phosphorus, and silica into the solution [12-15]. The most significant aspect of NovaMin, a special substance with many innovative properties, is its capacity to function as a biomimetic mineralizer, mimicking the body's inherent mineralizing characteristics [16]. The surface of the enamel treated by NovaMin was significantly smoother and more uniform. Bioactive glasses were reported as forming a surface layer of carbonated hydroxyapatite that was 100-150 micron thick in 12–24 hours.

Casein phosphor-peptides-amorphous calcium phosphate, or CPP-ACP, is the formal term for it [3]. It promotes the remineralization of carious lesions and inhibits the colonization of cariogenic bacteria on tooth surfaces by maintaining a supersaturated state of essential minerals. The mechanism of CPP- ACP involves the incorporation of Nano complexes into plaque and on tooth surfaces [18]. This localization keeps the high concentration gradients of calcium and phosphate ions in the subsurface enamel, which promotes remineralization [17]. It has been demonstrated that the CPP not only delivers and localizes ACP to the tooth surface but also stabilizes it. This location which buffers the free calcium and phosphate ion activities is the mechanism for CPP-ACP anti-cariogenic action [18].

Arginine, a common amino acid, has unique effects on the biofilm and the microbiota and has a stronger anti-caries impact than fluoride alone. Nowadays, arginine is marketed as a caries-preventive agent. It is an amino acid that is found in saliva, food, and proteins naturally. It is broken down by arginolytic bacteria and creates an ammonia-like substance, raising the pH of the oral biofilm and reducing the likelihood of acid-resistant bacteria growing in an acidic environment [2].

The appearance of teeth and their color is a significant issue [10]. Tooth color is closely associated with the structure of teeth, the total color effect resulting from absorbed and reflected light [24]. Based on color measuring techniques like CIE L*a*b* color coordinates, a great deal of research has been done on the color statuses of natural teeth and aesthetic restorative materials. Color difference (ΔE*) was calculated by the equation: (ΔE*)=[(ΔL*)2 + (Δa*)2 + (Δb*)2] 1/2 [11].

The objective of this study was to determine the most effective treatment method of NovaMin, CPP-ACP and Arginine containing toothpastes for esthetic improvement of demineralized WSLs by using colorimeter.

The null hypotheses tested was that no statistically significant difference between esthetic improvement of WSLs treated by three treatment methods.

MATERIALS AND METHODS

Sample Collection and Preparation

The sample comprised of thirty recently extracted impacted human third molars has normal size and intact buccal surface. The teeth were cleaned, washed with deionized water and kept in thymol solution 0.1%.

Teeth were cleaned, polished with non-fluoridated pumice and the

Remaining roots were cut 2mm below the level of cemento-enamel

Junctions using a straight diamond bur with a copious water irrigation [14]. One tooth was fixed at the top surface of the plastic ring in the center with the labial surface of the tooth exposed so that an enamel block of 4x4mm window was obtained [14]. The rings with the exposed surfaces of teeth were polished one by one with a fin grit silicon carbide papers (600–, 800–, and 2400–grit).

The Formation of Artificial Demineralized Lesion pH Cycle Procedure

Teeth samples were kept in the demineralizing solution (pH of 4.5) for 3 hours and in the remineralizing solution (pH of 7.0) for 20 hours. Teeth samples were washed with deionized water briefly between solutions and kept in the artificial saliva for 30 min. At the end of the demineralization and 30 min at the end of the remineralization process.it was repeated for 10 cycle and duration for each one is 24 hours .The demineralizing and remineralizing solutions were changed each day, and the artificial saliva were replaced after every treatment, the pH were measured to be sure that no changes of the pH readings will occur days later by using pH meter [17].

The Solutions Preparation

Demineralization Solution: consists of CaCl2 (2.2 mM), NaH2 PO4 (2.2 mM), and acetic acid (0.05 M), pH of 4.5, adjusted with KOH (1M), 15 ml/tooth [17].

Remineralization solution: consists of CaCl2 (1.5 mM), NaHPO4 (0.9 mM), KCl (0.15 mM), pH of 7.0, 15 ml/tooth [17].

Artificial Saliva: components of artificial saliva are NaCl 0.40, KCl 0.40, CaCL2 .2H2O 0.79, NaH2 PO4.2H2O 0.78, Na2S9.H2O 0.005, CO(NH2)2 Urea 0.1, in 1000 ml distilled water, pH of 7 (concentration G \ L) [22].

Study Samples Grouping Group 1 Arginine and fluoride a containing tooth paste(Colgate sensitive PRO__ Relief, Poland),

Table1 Consists of the teeth labial surfaces were subjected to ph cycling procedure for ten days and then Colgate tooth paste was applied, application of thin layer of paste on each tooth specimen by fine brush for one minute, then the teeth were washed with deionized water for 30 sec. And lightly dried with absorbent papers. These procedures were repeated two times daily for 7 days [19].

Group 2: Casein phosphopeptide-amorphous

Table 1: Description and composition of Colgate tooth paste

Material	Description
Colgate tooth paste	Colgate sensitive PRO__ Relief, Poland
	Composition: Sodium Monofluorophosphate 1.1%W/W(1450 Ppm F),Calcium Carbonate ,Aqua ,Sorbitol, Arginine, Sodium Lauryl Sulfate, Aroma, Cellulous Gum, Sodium Bicarbonate, Tetrasodium Pyrophosphate, Sodium Saccharin, Benzyl Alcohol, Xanthan Gum, Limonene , Ci77891

Table 2: Description and composition of CPP-ACP tooth mousse

material	Description
CPP-ACP tooth mousse cream	Topical cream with bio-available calcium and phosphate (GC America, Reclident, Alsip, USA). Composition: 10% by weight of CPP-ACP, glycerol, D-sorbitol, CMC-Na, silicon dioxide, propylene glycol, titanium dioxide, xylitol, phosphoric acid, flavouring, zinc oxide, magnesium oxide, butyl phydroxybenzoate, guar gum, sodium saccharin, ethyl p-hydroxybenzoate, propyl p-hydroxybenzoate, Pure water

Table 3: Description and composition of Sensodyne tooth paste

Material	Description
Sensodyne tooth paste	Nova Min containing paste NUPRO (Prophylaxis Paste with NovaMin; Gsk, Ireland.
	Composition: Glycerin, Pumice, 15% Calcium Sodium Phosphosilicate (Novamin), Sodium Silicate, Titanium Dioxide, Methyl Salicylate, Purified Water, Sodium Carboxymethylcellulose, Sodium Saccharin, Flavor

calcium phosphate (CPP-ACP)) Tooth Mousse Cream(GC America, Reclident, Alsip, USA)

Table 2 Consists of The teeth labial surfaces were subjected to ph cycling procedure for ten days and then CPP-ACP tooth mousse was applied, application of a thin layer of the cream on each tooth specimen by fine brush for 3minutes, then again the cream was distributed by the brush and left for 30 minutes then washed with de ionized water for 30 sec. And lightly dried with absorbent papers. This procedure was repeated two times daily for 7 days [6].

Group 3: Sensodyne tooth paste containing Novamin, NUPRO (Prophylaxis Paste with NovaMin; Gsk, Ireland)

Table 3 Consists of The teeth labial surfaces were subjected to pH cycling procedure for ten days and then 0.5 g of Sensodyne tooth paste was applied with a rubber cup to each tooth for 2 minutes in a clockwise direction. Then the teeth were immersed in deionized water for 2 minutes and then gently rinsed with deionized water for 30 sec. This procedure was repeated two times daily for 7 days [7].

Colorimetric analysis

The tooth surface colors were assessed using a colorimeter (3NHD65 /China). Three readings were taken on each tooth surface, and each reading was taken twice to confirm the same value and to ensure accuracy. Samples were dried with absorbent paper, and not desiccated, before reading. For WSLs, readings were taken at the center of the lesion. And all the measurements were done under standardized conditions. Readings were obtained with the device directed perpendicular to the site [12]. The results of color measurement were quantified in terms of the coordinate value L established by the Commission International de l'Eclariage (CIE) which locates the color of an object in a three-dimensional color space [23]. The L axis represents the degree of lightness within a sample and ranges from 0 (black) to 100 (white). The value represents the red/green axis, where an increase indicates a higher red color component. The b* value represents the yellow/blue axis, where an increase indicates higher yellow color component [12]. The color measurements were performed at three distinct times: sound enamel, after artificial white spots formation and after treatment [23]. The total color difference (ΔE) between different time intervals of the study was calculated by using the following formula: ΔE = [(ΔL)2 + (Δa)2 + (Δb) 2] ½ [11].

Statistical Methods: Statistical analysis of the results was performed by the SPSS Statistics (version 26.0, USA). Normality of distribution were assessed by Shapiro–Wilk test. Descriptive statistics mean, standard deviation, minimum and maximum values were reported. Both intragroup time points (sound enamel, after artificial white spots formation and after treatment) comparisons and intergroup comparisons were performed by using ANOVA and Duncan's post-hoc tests. The statistical significance of differences between the groups were accepted at the $P \leq 0.05$ level [19-22].

RESULTS

The Shapiro-wilk test of normality was done for data to determine the statistical tests needed to analyze the results. The results of the normality test showed that the data was parametric and normally distributed at $P \leq 0.05$. Table 4 shows the descriptive statistics of color values. Based on means values of color of sound teeth (S), after artificial white spots formation (W) and after treatment (T) groups within each group. In Colgate, GC, Sensodyne groups, the (W) group had highest value and the (S) group had lowest value. Comparison of 3 groups in color changes values (ΔL) after application of treatment materials were done, these color changes values had been calculated using the following equation:

ΔE post treatment (P)=[(L w-L T)2+(a w-a T)2+(b w-b T)2]1/2.

Table 5 shows the descriptive statistics of color changes values after application of three treatment materials. The results show that the highest change in color value was obtained in Sensodyne group and the lowest change

in color value was obtained in Colgate group. Table 6 demonstrates the comparison of mean values of color changes for the teeth in three groups by (ANOVA) test, and the results showed that there were statistically significant differences between and within groups (P ≤ 0.05).

Duncan's multiple analysis range test was done to further explain if that there was a significant difference of color changes values for samples. There were no significant differences between Colgate group and GC group, but there were significant differences between GC group and Sensodyne group and there were significant differences between Colgate and Sensodyne groups existed at P≤ 0.05. The highest value was for Sensodyne group and lowest value for Colgate group, Tables 4-7.

DISCUSSION

Color plays an important role in obtaining optimum aesthetics. In first demineralized enamel lesions, mineral loss and increasing surface roughness increase light scattering, reduce translucency, and increase opacity [23].

In the current study, the null hypothesis which said that no statistically significant difference between esthetic improvement of demineralized WSLs treated by three treatment approaches was rejected, as there was statistically significant difference between esthetic improvement of demineralized WSLs treated by three treatment approaches. When making comparison between three approaches, it has been found that Sensodyne tooth paste has best ability in color improvement of tooth enamel, this was agreement with [16] who stated that "when saliva comes into contact with calcium sodium phosphosilicate, it breaks down and releases sodium, which then exchanges with hydrogen cations (H+ or H3 O+) to release calcium (Ca+2) and

Table 4: Descriptive statistic of color values of(S),(W),(T) groups within each groups

Groups		Sound teeth(S)	After artificial WSL formation(W)	After treatment(T)
Colgate	N	10	10	10
	Mean	64.17	66.45	65.24
	Std	5.06	5.56	5.02
	Minimum	54.77	57.08	56.79
	Maximum	72.77	76.53	74.43
GC	N	10	10	10
	Mean	67.03	69.74	67.96
	Std	6.88	5.03	5.8
	Minimum	48.93	57.75	52.82
	Maximum	72.85	75.46	72.92
Sensodyne	N	10	10	10
	Mean	66.59	69.4	68.22
	Std	6.28	4.88	5.07
	Minimum	53.86	58.75	56.83
	Maximum	72.67	74.19	73.34

N=number of sample, Std=standard deviation, GC=GC tooth mousse

Table 5: Descriptive statistics of color changes values of Colgate, GC and Sensodyne groups, post treatment

Groups	Number of sample	Mean	Std	Minimum	Maximum
Colgate	10	2.57	1.13	1.24	4.48
GC	10	3.32	1.46	1.52	5.36
Sensodyne	10	4.8	2.11	1.9	7.64

GC= GC tooth mousse, Std=standard deviation

Table 6: ANOVA test for color changes mean values between three groups (Colgate, GC and Sensodyne)

Color Changes	Sum of Squares	df	Mean Square	F	Sig*
Between Groups	26.006	2	13.003	4.967	0.015
Within Groups	70.682	27	2.618		
Total	96.687	29			

significant difference at P≤ 0.05, df=degree of freedom, F=F-test

Table 7: Duncan's Multiple Analysis Range Test for (Colgate, GC and Sensodyne) groups.

Groups	N	Subset For Alpha = 0.05	
		1	2
Colgate	10	2.57	
GC	10	3.32	
Sensodyne	10		4.8
Sig.*		0.31	1

significant difference at P≤ 0.05,N=number of sample, GC= GC tooth mousse

phosphate (PO4-2) ions from the particle structure. The precipitation of calcium and phosphate ions from saliva and the particles to create a calcium phosphate layer on the tooth surfaces are caused by a brief rise in pH. Chemically and physically comparable to biological apatite, Calcium-phosphate complexes crystallize to produce hydroxycarbonate apatite". Sensodyne followed by GC tooth mousse which also has ability to improve the color of tooth due to the fact which determined by [24] who stated that " in terms of the extent and color of the post-orthodontic WSL reduction, CPP ACP have seen desirable and long-lasting aesthetic improvement". However, this is in contrast to a research by [26], who claimed that post-debonding WSL did not significantly alter in color following CPP-ACP administration. But Colgate tooth paste has lowest ability to improve the enamel color and make masking for color of WSL. This result was in agreement with [25] who claimed that although arginine toothpaste enhanced crystal deposition, the structure could not be entirely restored to that of natural enamel. On other hand this study did not agreed with study of who have been concluded that Arginine dentifrice can remineralized early caries lesions by increasing the production of alkali in dental plaque biofilm and bringing up pH levels through the production of ammonia, which is produced by the metabolism of arginine through the arginine deiminase pathway of specific oral bacteria [26].

Limitations of the study

There are some colorimetric limitations that need to be considered in the interpretation of the present findings.

The tooth surface is not flat, the color measurement were depended on the surface form of sample. A more accurate result will be obtained, if the surface is flat.

During measurement, even very slight movement in colorimeter device over tooth surface affects color readings.

CONCLUSIONS

Within the limitation of the present study, the following conclusions were reached

Sensodyne (containing Novamin) tooth paste and GC (containing CPP-ACP) tooth mousse considered effective agents in color improvement of artificial WSL and restore the natural color of enamel and decrease chalky appearance of enamel, but with different capacity.

Sensodyne (containing Novamin) tooth paste had superior color improvement of WSL.

Colgate (containing Ariginine) tooth paste had little effect in color improvement the of enamel WSL.

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