Effectiveness of Utilization of Different Remineralizing Agents on Tooth Color During Orthodontic Treatment

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Abstract

Objective: To evaluate the effect of 3 different topical agents utilized for prevention of enamel demineralization on tooth color during orthodontic treatment.

Materials and Methods: Metal orthodontic brackets were bonded to forty human maxillary premolars. The teeth were randomly divided into 4 equal groups (A, B, C, and D). Group A: control (No preventive agent was used). In groups, B, C, D: Clinpro white varnish, Enamel-Pro varnish and MI Paste Plus were applied to the buccal surface of the teeth around the brackets respectively. Spectrophotometer was used for assessing the change in the enamel color through taking before bonding and after debonding measures. The data was statistically analyzed using paired sample t-test, Kruskal Wallis test, and One-way ANOVA test.

Results: Paired sample t-test illustrated significant differences regarding Hue (a) and Chroma (b) ($p \le 0.05$). While no significant difference was found between the before bracket bonding and after debonding in the Lightness (L) measurement for all study groups ($P > 0.05$) except in Clinpro group ($p \le 0.05$). Kruskal Wallis test showed no statistically significant difference between the four groups in color change assessment ($P > 0.05$). One-way ANOVA test revealed no statistically significant differences in ΔE of the four studied groups ($P > 0.05$).

Conclusions: Clinpro®, Enamel-Pro and MI Paste Plus could be used safely for 6 months without any deleterious effects on the tooth color.

Key words: Tooth color; Enamel demineralization; Topical agents

Introduction

Preservation of oral hygiene in fixed orthodontic appliance patients is difficult. The banding and bonding procedures facilitate plaque accumulation. Streptococcus mutans are the most prominent dental plaque organisms which ferment the dietary carbohydrate to produce an adhesive polysaccharide (dextran) and lactic acid. The low PH of the plaque obstructs the remineralization process as the lactic acid attacks the enamel before its removal by the salivary flow so enamel decalcification occurs.1 Several studies reported that formation of white spot lesions (WSLs) around orthodontic attachments can occur as early as 4 weeks of treatment and in 50 % of fixed orthodontic patients [1-3].Several modalities have been utilized in prevention of WSLs including application of fluoride derivatives such as fluoride toothpaste, fluoridated mouth rinse, fluoride gel and foam, fluoride varnishes, fluoride releasing sealant or coat, fluoride releasing elastomers, xylitol, usage of Recaldant group like casein, application of chlorhexidine, ozone and laser irradiation [4-7].

Sodium fluoride (NaF) is considered the most common agent used in the prevention against decalcification. Enhancement of its effect can be occurred either by addition of amorphous calcium phosphate as in Enamel Pro varnish which increases the adhering time and effect to the surface of enamel than any other topical fluoride with the formation of more resistant enamel. [8] Tricalcium phosphate (TCP) combined to NaF such as Clinpro varnish improves the levels of fluoride embodiment forming stronger and better acid resistant minerals in the surface enamel layer. [4] Recaldent group including casein phosphopeptide amorphous calcium phosphate (CPP-ACP) with fluoride has been observed to affect positively the WSLs by being protein–based systems derived from milk. [9]

Preservation the color of enamel through the different stages of orthodontic treatment is one of the major concerns to the orthodontist. Many factors affect enamel color including dietary as coffee, aging due to wearing away of the outer layer of enamel revealing the natural yellow color of dentin, excessive fluoride uptake either from environmental or synthetic sources and medications as tetracycline. Dental materials such as amalgam restorations, mouth rinses containing chlorhexidine can also cause teeth discoloration. [10]

Measurements of tooth color can be conducted by several means such as spectrophotometer which allows a good opportunity to detect the lightness, saturation and accurate color specification.[11] Another method for color determination is the Optical coherence tomography (OCT) which projected onto the surface of the object across the tested area in two dimensions through utilization of hand-held probe with analysis of the backscattered light to detect the correct color precisely.

[12]Quantitative Light-Induced Fluorescence (QLF) system measures the fluorescence loss following demineralization of enamel. [9] An ancient primitive method was used for color determination including a mirror and head light.[11] Therefore this study was conducted to evaluate the efficacy of Enamel Pro varnish, Clinpro varnish and CPP-ACFP in the preservation of the natural color of the teeth.

Materials and methods

Sample preparation

This study was operated on 40 human maxillary first premolar extracted as a regime of orthodontic treatment. Sample size was determined depending on a previous study by Borges et al whose sample size of 10 teeth achieved 97% power to detect a difference of -2.4 between the null hypothesis mean of 0.0 and the alternative hypothesis mean of 2.4 with an estimated standard deviation of 0.9 and with a significance level (alpha) of 0.001 using a two-sided Wilcoxon test assuming that the actual distribution is normal [1].The premolars were selected according to the following criteria: Intact buccal surface, free from any pits, cracks or extraction damage and without presence of any caries, dental fluorosis or other hypomineralized lesions. Following the extraction, residues on the teeth were removed and washed away with tap water, and then the teeth were stored in distilled water at approximately 37° C.14

The buccal surface of all the teeth was cleaned with a slurry of non-fluoridated pumice powder and water using rubber prophylactic cup then rinsed with water spray and dried with compressed air. [15] The bucco-lingually crown width of the teeth under experiment was measured accurately with a digital caliper in the middle of the teeth at the maximum height of contour. The enamel surface was covered with a polyvinyl siloxane material (Affinity, Clinician's Choice, New Milford, USA). A circular hole with 6 mm diameter was made by measuring 4 mm distance from the cusp tip at the middle of the buccal tooth surface and locating a point from which a circular opening is made with 3 mm radius. This latter step was made for allowances of proper contact with the tip of the spectrophotometer to construct a constant standardization area.[9]

Bonding procedures

Metal premolar Roth brackets with 0.022 inch slot (3M, Unitec, California, USA) were bonded to the buccal surface of all teeth 4 mm from the cusp tip. Firstly, the enamel buccal surface was covered with an adhesive tape. A window was made in the tape for specific measured area at the middle of the teeth equal to the size of the bracket. Enamel etched with 37% phosphoric acid gel (Eco-Etch, Ivoclar Vivadent, Liechtenstein, V30024) for 20 seconds then rinsed with distilled water, and air-dried for 5 seconds. Transbond XT primer (3M Unitec) was applied to the etched enamel using a micro brush. Transbond XT adhesive resin (3M Unitec) was placed on the bracket base. Then, the brackets were pressed properly against the enamel surface in their planned position. The excess adhesive was removed with a sharp hand instrument. Finally, light curing was done for 20 seconds and the adhesive tape was removed.

Group's allocation

After bonding, the teeth were randomly allocated into 4 equal groups (A, B, C, and D) according to the demineralizing preventive agent used. In group A: No demineralizing preventive agent used (Control). In group B: 1.1% NaF with tri-calcium phosphate (Clinpro 5000, 3M ESPE St. Paul, MN, Minnesota, USA) was used. A thin ribbon of it was applied using a soft-bristled toothbrush with a gentle circular movement for about 2 minutes, left for 4 hours then water rinsing occurred. In group C: 5% NaF varnish in ACP formula (Enamel Pro, Premier Dental Products Company, Romano Drive, Pennsylvania, USA) was utilized. Its application occurred by accompanied specific brush and retained for 5 hours undisturbed through this period. In group D: CPP-ACP with 0.2%, NaF (MI Paste Plus, GC Europe N.V Interleuvenlaan, Leuven, Belgium) was applied. It was painted and left undisturbed for 5 minutes then removed with a cotton roll and washed with tap water for removal of the residue. Application of either Clinpro or Enamel-Pro was done immediately after bonding, after 2 months then after 4 months of bracket bonding. On the other hand, MI Paste Plus was applied daily through the whole duration of the research. All tested materials were applied to the buccal surface around the bracket according to manufacturer instructions.

Imitation of oral solutions

After application of decalcification preventive agent, each sample washed with tap water, dried by absorbent paper. Then the teeth were immersed in 4 solutions resembling oral media; demineralizing solution for 30 min per day, remineralizing solution for 2.5 hours, artificial saliva for 6 hours and deionized water for 14 hours (Table 1).9 All teeth were rinsed with tap water and dried with absorbent paper between every step. The rest 1 hour was for application of the tested agents. The cycle repeated every day with weekly replacement of the solutions. Each tooth was cleaned using an electronic dental brush (Oral-B, Braun GmbH, Germany) and Crest Cavity Protection toothpaste (1450 ppm F) was placed on the brush bristles and slightly applied around the bracket for 2 minutes twice daily to mimic the normal day life care of the patient.

Measurement of the tooth color

Spectrophotometer (Vita Easyshade, Vita Zahnfabrik, Bad Säckingen, Germany) was used for precise measuring of the degree of color change of the buccal enamel surface of the examined teeth. This mobile device consists of a digital pointer with 6 mm diameter, 19 fiber optics for precise illumination of the tooth surface and spectrophotometric sensors for determination of color in a numeric way. The assessment of color depends on the color space system of CIELAB (Commission Internationale de l'Eclairage L*, a* and b*) using 3 parameters of color: degree or value of lightness (L) which started from 0 that means black and ended by 100 which means white, Hue measurement (a) ranging from (positive a) equal to red to (negative a) equal to green and Chroma measurement (b) as (positive b) means yellow to (negative b) which means blue.

Then delta E (ΔE) was calculated through the following equation $\Delta E = [(L2-L1)2+(a2-a1)2+(b2-b1)2]1/2$.

The tip of the spectrophotometer was positioned in the corresponding circular hole in the polyvinyl siloxane coverage surrounding the teeth in a perpendicular position and flushed with the buccal tooth surface. For all tested teeth, 3 shade readings were taken in a dark box. Two color evaluating sessions was assessed: the first one was before bracket bonding, while the second one after brackets debonding and removal of excess adhesive with a high speed carbide bur (after 6 months from the beginning of the study). Calibration of the spectrophotometer occurred every time before measuring the color of tooth specimen.

Statistical analysis

Data were collected and analyzed using IBM-SPSS Statistics for Windows, version 21.0. IBM Corp. The data were tested for normality using Shapiro-Wilk test. The data were expressed as Mean and standard deviation (SD) if normally distributed or Median if not normally distributed. Wilcoxon Signed Rank Test was utilized to compare between the means of buccolingual crown width before bracket bonding and after debonding and removal of excess adhesive. The Measurements of Lightness (L), Hue (a) and Chroma (b) before bracket bonding and after debonding and removal of excess adhesive was evaluated using paired sample t-test for each study group. Kruskal Wallis test was utilized to evaluate the significant difference in the changes of (L, a, b) among the four studied groups. One-way ANOVA test was used to compare by means of the different study groups. All tests were conducted at 0.05 level of significance.

Results

The buccolingual crown width (mm) for the four studied groups between the before bracket bonding and after debonding measurements and the results of Wilcoxon Signed Ranks Test are illustrated in table (2). No significant difference was detected (p > 0.05).

The means and standard deviation (SD) of Lightness (L), Hue (a) and Chroma (b) respectively before bracket bonding and after debonding for all studied groups and the results of paired sample t-test are presented in tables (3-5). There were significant differences between the before bracket bonding and after debonding measurements regarding a, b (p ≤ 0.05). On the other hand, no significant difference was found in the L measurement before bracket bonding and after debonding for all studied groups (P > 0.05) except in Clinpro group (p ≤ 0.05).

The medians of the change in the color measurements (L, a, b) before bonding and after debonding are illustrated in table (6). The results of Kruskal Wallis test showed no statistically significant difference between the four groups (P > 0.05).

The means and standard deviation of Δ E of the four studied groups are presented in table (7). One-way ANOVA test revealed no statistically significant differences between the four studied groups (P > 0.05).

Discussion

The present study was conducted to evaluate the effect of 3 different topical enamel demineralizing preventive agents on the color of the teeth. For standardization, one type of teeth was selected (maxillary first premolar). Enamel thickness has a strong relationship with the tooth color as thin enamel allows the yellowish color of the dentin to appear remarkably as reported by Joiner (2004). The thickness of the enamel was evaluated in between the 4 groups. No significant difference was present (p ≤ 0.05). In addition, all teeth were subjected to demineralization/remineralization cycle to mimic the oral environment. The amount of etched enamel was standardized to avoid the effect of excessive etching on the enamel and subsequent tooth color. The area of color assessment was the same before bonding and after debonding since the enamel color could be different from an area to another in the same tooth. Also, color assessment was occurred in dark box to avoid the effect of any surrounding light sources. Color evaluation was done using spectrophotometer which is accurate in color selection as investigated by Judeh et al, Silame et al and Tafaroji et al. [10,11,14]. The color readings were taken depending on the color space system of CIELAB and Munsell's percentile units color system. This latter system produces numeric information that has an accurate relationship to the actual visual response making it popular in the measurement of color.

The results of the present study regarding the change in the Lightness before bonding and after debonding showed no significant difference (P > 0.05) in all groups except in Clinpro group (p ≤ 0.05). In the latter, the teeth became whiter on the black-white scale as the Lightness values after debonding was significantly higher than before bonding. Regarding the Hue and Chroma measurements, the after debonding values were significantly higher than those of before bonding (p ≤ 0.05). This means that the color of the teeth moves toward the green direction in the red-green scale and toward the blue direction in the yellow-blue scale. However, no significant difference was found either in the difference between L, a, b before bonding and after debonding or in ΔE in between the 4 studied groups (P > 0.05). This could be attributed to the application of the tested materials for a short period so the effect of this material should be evaluated for a longer period. These findings are in harmony with those of Beerens et al and Brochner et al who found no significant difference in the tooth color with the utilization of either MI Paste Plus and the routine oral hygiene measurements. Also, the results were in line with those of Hammad et al who revealed no clinically significant difference between SeLECT-Defense, Clinpro, and Enamel-Pro on the color of the teeth. On the other hand, the results of the present study were in disagreement with those of Robertson et al and Bailey et al who found significant differences in the tooth color with the utility of MI Paste. In addition, Paschos et al concluded that Clinpro preventive agent has superiority on color preservation than Proseal. These counter act could be declared to the types and amount of preventive agents and duration of the study. The duration of the current study was 6 months while it ranged from 1-3 months in Paschos et al and Robertson et al.

Conclusion

According to the results of the present study, it could be concluded that Clinpro, Enamel-Pro and MI Paste Plus could be used safely for 6 months without any hazards on color change.

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