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Effect of Whitening Toothpastes with Different Whitening Agents on the Color Stability of Orthodontic Clear Elastic Ligatures

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ABSTRACT

Background/Purpose: *The demand for invisibility appearance of fixed orthodontic appliances result in increase the use of ceramic brackets with clear auxiliaries. Elastic ligatures are one of the most widely used materials in fixed orthodontic treatment and susceptible for discoloration. The aims of this study were the evaluation and comparison the effect of brushing orthodontic clear elastic ligatures by whitening toothpastes with different whitening agents on the color stability of them.* ***Materials and method:*** *The sample consisted of whitening toothpastes: Kin Progressive White (Fabrique par, Barcelona, Spain), Lacalut White (Germany), Silca Brilliant White (Germany), and Opalescence White (UT, USA), also Kin Regular (Fabrique par, Barcelona, Spain) (control). Sixty Ormco Clear Ligatures (Scafati, Italy) used in the study, these ligatures exposed 1 hour daily to dietary media (Mixture of tea, coffee, turmeric, and mineralized water) (pH=4.6) and each 10 specimens brushed with one type of toothpaste, except 10 elastics without brushing. After 4 weeks, the ligatures were assessed by a cellular attachable microscope that connected to the mobile phone according to CIE L*a*b* color system by the Adobe Photoshop program.* ***Results:*** *The resulting data were statistically analyzed using ANOVA and Tukey's HSD tests which showed that the highest mean value of color change was observed in no brushing ligatures followed by Silca Brilliant White, Lacalut White, Kin Progressive White, Opalescence White, the lowest value of color change was Kin Regular. Furthermore, the increased mean value of color change was mainly affected by (CIE b* axis).* ***Conclusion:*** *Kin Regular toothpaste without whitening agents decreased the color change of clear ligatures more than others after exposure to staining media.*

Keywords: Elastomer, Whitening toothpaste, Color change, Ligature

INTRODUCTION

One of the major demands of the patients especially the adults during orthodontic fixed appliance therapy is the attractive appearance [1-3]. The aesthetic brackets were increasingly used instead of stainless steel brackets in the orthodontic treatment due to the improvement of their mechanical and optical properties. Ceramic and polycarbonate brackets had good color stability and are nearly resistant to visually observable dietary pigment discoloration [4-6]. Patients who seek invisibility of orthodontic appliances usually desire colorless elastic ligatures that supplement the good appearance of esthetic brackets. However, after a few weeks, yellowing of these elastics is visibly clear due to the effect of food and drinks in the oral environment that stain and alter the surface of the elastomeric, causing esthetic degradation [7,8]. Pigmentation of orthodontic ligatures usually depends on the type of ligature, commercial brand, and the effect of pigmenting agents [6,9]. The brushing procedure and the type of toothpaste may also affect the color stability of dental materials [10]. Some toothpastes contain bleaching (whitening chemicals), abrasive system, and specific pigments that aim to improve the tooth aesthetic quality [11,12]. The use of toothpastes with whitening characteristics could decrease loss of aesthetic appearance caused by increasing ligature staining, thus increasing patient's satisfaction with orthodontic therapy, and reducing the extra costs of additional clinical visits [13]. The purpose of this study was to investigate the influence of brushing orthodontic clear ligatures with whitening

toothpastes (containing different whitening agents and offered by different manufacturers) on the color stability of these ligatures after exposure to staining media.

MATERIALS AND METHODS

Sample

The sample includes 60 Ormco Clear Elastomeric Ligatures (Scafati, Italy) used in the study. Kin Progressive White (Fabrique par, Barcelona, Spain), Lacalut white (Germany), Silca Brilliant White (Germany), and Opalescence White (Ultradent co, South Jordan, UT, USA), also Fluor. Kin Regular (Fabrique par, Barcelona, Spain) (control) were tested.

Storage Media

The ligatures were encircled on around brackets (Forestadent, USA) that fixed to polymethyl methacrylate block with ethyl cyanoacrylate (glue), 10 brackets were bonded to each block. A straight orthodontic stainless-steel wire (Orthotechnology) was situated through the brackets to mimic *in vivo* ligature stretching. In total, 60 elastic ligatures were situated around brackets. The elastics were exposed for 1 hour daily to dietary media (mixture of tea, coffee, turmeric, and mineralized water) (pH=4.6) at 37°C, then they brushed and washed with distilled water and stored in artificial saliva (pH=6.7 ± 0.10) at 37°C for 23 hours. The immersion media were changed daily for all groups.

Brushing Procedure

- **Group A (40 specimens):** Will be brushed daily with whitening toothpaste (each 10 specimens will be brushed with one type of four different brands of whitening toothpastes).
- **Group B (10 specimens):** Will be brushed daily with Regular toothpaste.
- **Group C (10 specimens):** Will be left without brushing.

Soft-bristled Rotary tooth brush (Oral-B Electric rechargeable tooth brush) will be used which fixed at a constant distance by holder with load application during brushing (155 g) measured by portable digital balance. Pea-sized amount of toothpaste on the tooth brush [14-16]. The brushing time for each bracket-ligature specimen was 1 minute [13,17]. The specimens were maintained in contact with the toothpaste slurry for an additional 1 minute after brushing for improved contact of the toothpaste with the ligatures. Then rinsed with distilled water. One toothbrush for each 10 specimens in each group was used.

Measurement of the Color Changes

After 4 weeks, an X-ray viewer with a black opaque paper had a central hole of 3 mm radius was used to reduce the light reflection and improve image quality. Each elastic was placed in the center of the hole. The cellular attachable microscope was attached to the mobile phone running Android software and J-cam application. The microscope was placed above the ligature, so its border was in close contact with the x-ray viewer. A snapshot was taken for each ligature under x2 and kept in the phone's memory. Then these photos were transmitted to the laptop computer and unlocked in commercial software (Adobe Photoshop 2015, version 7.0 Model: 5; Adobe Systems ME., San Jose, California, USA). Four areas were selected from up, down, right, and left sides of module by using the 'eyedropper' tool for each elastic [18]. The calculation of color changes by using the CIE Lab System (Commission Internationale de ´Eclairage).

In the CIE Lab uniform color space, the coordinates were:

L: The lightness coordinates.

a: The red/green coordinate with +a representing red and -a representing green.

b: The yellow/blue coordinate with +b representing yellow and -b representing blue.

The total color difference ΔE for each specimen was calculated by the following equation [19]:

$$\Delta E^{*} = \left(\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}\right)^{\frac{1}{2}}$$

Color measurements for each elastic specimen was made before and after immersion and brushing.

Statistical Analysis

Data were collected and analyzed by using statistical package of social science program software version 21. In this study the following statistics were used:

A. **Descriptive statistics:** Including mean, standard deviation, frequency, and statistical tables.

B. **Inferential statistics:**

1) One-way analysis of variance (ANOVA) test.

2) Tukey's honestly significant difference test (HSD) when ANOVA test was statistically significant.

In the statistical evaluation, the following levels of significance are used: P>0.05 was considered as non-significant; $0.05 \geq P > 0.01$ was considered significant and; $P \leq 0.01$ was considered as highly significant.

RESULTS

The means, standard deviations, minimum and maximum values of the color change are presented in Table 1.

Table 1 Descriptive statistics of the color changes of the elastic ligature after brushing with different tooth pastes

Tooth pastes	Descriptive statistics			
	Mean	Standard Deviation	Minimum	Maximum
No brushing	78.497	1.643	75.531	80.752
Kin Regular	62.891	1.104	61.135	64.682
Silca Whitening	75.913	0.882	74.228	77.093
Kin Whitening	68.796	1	68.021	71.524
Opalescence Whitening	65.355	1.132	64.023	67.791
Lacalut Whitening	75.014	1.15	73.464	77.745

It was obvious that no brushing group had the highest mean value of color changes followed by whitening toothpaste groups. Regular Kin toothpaste group had the lowest mean value of color change. Among whitening toothpaste groups, Silca Brilliant White was the highest mean value of color changes followed by whitening Lacalut, Kin Whitening, and Opalescence Whitening. All the color components (ΔL, Δa and Δb) showed that the highest (ΔL) values (Figure 1) was in whitening toothpastes more than no brushing and regular kin toothpaste groups. While ligatures brushed with whitening toothpaste had lower (Δa) values (less red) than ligatures brushed with regular toothpaste (Figure 2). The CIE b* values (Figure 3) was higher in no brushing group and the whitening toothpaste more than the regular toothpaste groups. ANOVA test showed high significant differences of ∑ΔE for all comparable groups (Table 2).

Table 2 Comparison of ΔE values among different groups

ANOVA test	
F-test	p-value
287.591	0.00

When these differences were tested by Tukey's HSD test, Silca Whitening showed a non-significant difference with Lacalut Whitening (Table 3).

Table 3 Tukey's HSD test after ANOVA test of Ormco clear elastic ligatures

Toothpaste		Ormco	
		Mean Difference	p-value
No Brushing	Kin Regular	9.693	0.00
	Silca Whitening	3.818	0.00
	Kin Whitening	4.031	0.00
	Opalescence Whitening	6.877	0.00
	Lacalut Whitening	5.138	0.00
Kin Regular	Silca Whitening	-5.875	0.00
	Kin Whitening	-5.662	0.00
	Opalescence Whitening	-2.815	0.00
	Lacalut Whitening	-4.554	0.00
Silca Whitening	Kin Whitening	0.213	0.00
	Opalescence Whitening	3.059	0.00
	Lacalut Whitening	1.32	0.531
Kin Whitening	Opalescence Whitening	2.847	0.00
	Lacalut Whitening	1.108	0.00
Opalescence Whitening	Lacalut Whitening	-1.739	0.00

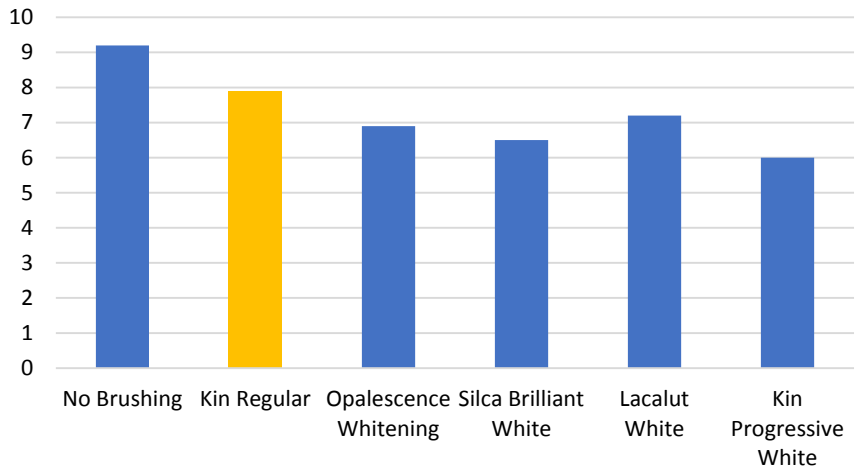

Figure 1 CIE L* (shaded yellow) values of Ormco ligatures under storage conditions, toothpaste types. The regular toothpaste had lower luminosity compared to the whitening toothpastes

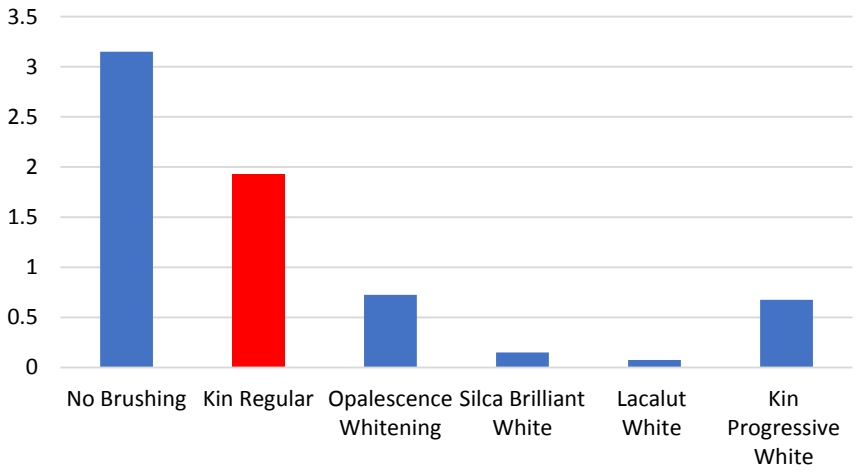

Figure 2 CIE a* (shaded red) values of Ormco ligatures under storage conditions, toothpaste types. The whitening toothpastes had lower redness compared to the regular toothpaste

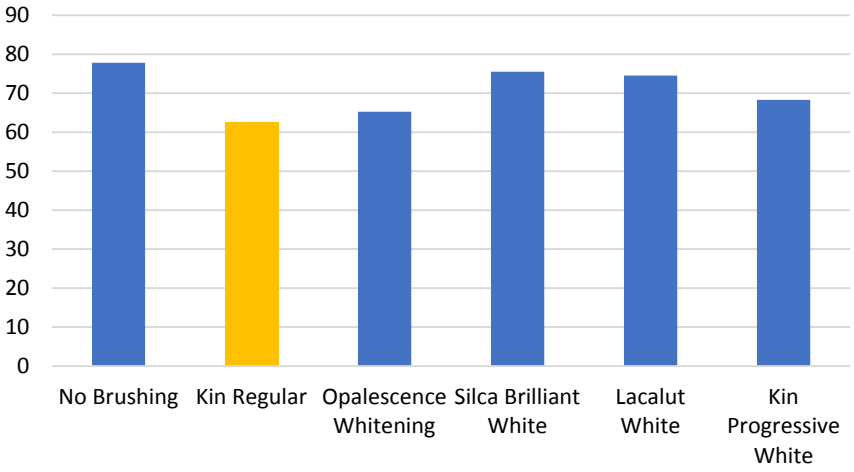

Figure 3 CIE b* (shaded yellow) values of Ormco ligatures under storage conditions, toothpaste types. The CIE b* was higher when the whitening toothpaste was used

DISCUSSION

This *in vitro* study was assumed to test the effect of the whitening toothpaste on the color stability of stretched clear elastomeric ligatures. Ormco (Scafati, Italy) clear elastic ligature was used in this study. And five toothpastes: Fluor. Kin Regular (fabrique par, Barcelona, Spain), Kin Progressive White (Fabrique par, Barcelona, Spain), Lacalut White (Germany), Silca Brilliant White (Germany), and Opalescence White (Ultradent co, South Jordan, UT, USA), were tested. These specific types of whitening toothpastes were taken because they are usually available in the market, and the manufacturers claimed that they eliminate pigments and progressively whiten teeth. The present study evaluated the discoloring effect of two well-known drinks that consumed daily by the patient (tea and coffee) on elastomeric modules, also turmeric was added to this study because of its widespread use in cooking. Since recent researches had been evaluated the discoloration effect of turmeric on esthetic brackets and elastomeric modules [5,20,21]. The ligatures were tested in a stretched arrangement to produce a clinically related system. Staining is more likely to happen under stretching due to greater pigment absorption. In addition, the low pH of the dietary medium (pH=4.6) increase the susceptibility of ligature surface for more coloring absorption [22]. One-hour daily exposure to dietary medium could also be considered a severe pigmentation state, as diet-mediated pigmentation is result from continuous low-level contact with oral stains [13]. The results of this study showed that there were less ΣΔE*mean values in Kin Regular toothpaste group of elastics than other comparable whitening groups which may be due to absence of whitening agents in regular toothpaste composition that may be increase elastic surface roughness and susceptibility for more pigment absorption. Also, there were slight deceased in ΣΔE*mean values in Opalescence toothpaste group of elastics this may be due to effect of blue Covarine that decreased yellow discoloration. The bleaching influence of Blue Covarine is established on altering the perception of tooth color by put down a thin blue layer on the surface of enamel (an optical effect) [11]. The ΣΔE*mean values of whitening kin toothpaste group of elastics less than Silca and Lacalut groups this may be due to the decreased effect of abrasive (sodium bicarbonate). The sodium bicarbonate is desirable abrasive for toothpaste compositions because it is low in abrasion. Sodium bicarbonate particles are relatively soft as compared to most conventional abrasive materials used in toothpaste compositions [23,24]. There were highly significant ΣΔE*mean values in Lacalut toothpaste group of elastics this may be due to combinations of abrasives: Hydrated silica and silica (dual silica system) which may be increased abrasion rate due to abrasion particles size or their amount and as a result surface roughness of elastics will increase. The abrasive wear rate increases linearly as the particle concentration till most of particles being arrested by the brush [12,25]. There were highly significant ΣΔE* mean values in Silca toothpaste group of elastics this may be due to carbamide (bleaching agent) that weakened the elastic chemically as it produced morphologic changes, causing increase in the surface roughness [26]. In addition, the presence of hydrated silica (abrasive) increase scratching rate of elastic surface and increase susceptibility for pigment absorption.

CONCLUSIONS

- The color of clear elastomeric ligatures increased after exposure to staining agent.
- Regular toothpaste may reduce color change values of ligatures more than whitening toothpastes.
- Among the whitening toothpastes, the whitening toothpaste that contain optical whitening agent (Blue Covarine) can be a better alternative than others as this pigment will decrease yellow discoloration and increase blue coloration.

DECLARATIONS

Conflict of Interest

There are no potential conflicts of interest, personal, financial, or otherwise with this work for authors and planners.

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