Color Stability of Different Aesthetic Archwires (An *In vitro* study)

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ABSTRACT

Background: Coated aesthetic archwires are currently the existing solutions for the esthetic problem, but the color of these archwires tends to change overtime. This study was aimed to evaluate the color stability of different types of esthetic archwires from four different companies at different time periods after immersion of two different staining drinks which are tea and Pepsi cola.

Materials and methods: 48 specimens were prepared, each specimen contains 10 aesthetic archwires; and were divided according to type of solution into two groups: A (tea) &B (Pepsi cola); each group contained 24 specimens (12 specimens were immersed in the staining solution as 4 specimens for each time intervals and 12 specimens were immersed in distilled water as control group). Each subgroup contains one specimen from each company. Color measurements were performed by means of a computed spectrophotometer according to the Commission Internationale de l'Eclairage L*a*b* system, and color changes (ΔE*) and National Bureau of Standards units.

Results: Both staining solution caused color change in variable degree and the higher amount of color instability was found for the archwires from the Hubit Company while the least amount of color change was for the archwires from the Orthotechnology Company.

Conclusion: The tea caused highly significant change on the aesthetic archwires which is higher than the effect of the Pepsi cola.

Key words: Color stability, aesthetic archwires, staining drinks. (J Bagh Coll Dentistry 2016; 28(1):164-168).

INTRODUCTION

Esthetic of the patient, is one of main concerns during orthodontic treatment. There is a growing demand for esthetic appliances because most fixed orthodontic appliance components are metallic and silver in color, the demand for esthetic orthodontic appliances is increasing, and the development of materials that present an acceptable esthetics for the patients and an adequate clinical performance for clinicians is needed, this demand has led to the development of orthodontic appliances that had an acceptable esthetics both for patients and clinicians [(1,2)].

The problem has been partially solved by the introduction of esthetic brackets made of ceramic or composite, which are becoming more popular. However, most archwires are still made of metal such as stainless steel and nickel-titanium. A number of alternatives have been explored to create an esthetic archwire that would allow efficient orthodontic treatment from the labial aspect [(3,4)]. Metallic archwires coated with tooth-colored resin materials, such as synthetic fluorine-containing resin or epoxy resin composed mainly of poly-tetra-fluoro-ethylene, are currently the existing solution to this esthetic problem, ideally, the color of esthetic archwires should match that of natural teeth and esthetic brackets [(5-7)].

The color stability of esthetic archwires during orthodontic treatment is clinically important, any staining or discoloration or change in esthetic of patient will affect the cooperation and acceptance to his treatment, color instability of these wires and exposure of the underlying metal is also often reported. It has been found that 25% of coating is lost in 33 days intra-orally, therefore, the wire becomes aesthetically degraded [(8)]. Coating improves esthetics but has some disadvantages, the color tends to change with time coat as "un-durable", like other esthetic orthodontic products, and there are internal and external causes for the discoloration of esthetic archwires [(9)].

External discoloration can be caused by food dyes and colored mouth rinses, the type of coating material and its surface roughness play decisive roles in the extent of the discoloration caused by diverse substances. The amount of color change can be influenced by a number of factors, including oral hygiene and water absorption [(10)].

MATERIALS AND METHODS

The Samples

In this study, four brands of esthetic archwires were assessed. The brands, cross section size, composition, and coating surfaces are shown in table 1, as described by the manufacturers.

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Table 1: Characteristics of the Esthetic Archwires Used in the Study

Company	Cross section size	Coating type	Composition
Hubit company / Korea	0.019 * 0.025”	Polytetrafluoroethylene	Stainless steel
Dany BMT Company / Korea	0.019 * 0.025”	Polytetrafluoroethylene	Stainless steel
Orthotechnology company / U.S.A.	0.019 * 0.027”	Epoxy	Stainless steel
G &H Wire company / U.S.A.	0.019 * 0.025”	Epoxy	Stainless steel

Twelve samples from each company were prepared; each sample was made by cutting the preformed archwires into two halves, then placing ten halves of the coated archwires segments together and uniting there free ends first by the light cure composite resin because it has quick set so it makes it easier to use the ethyl cyanoacrylate (Ameer) for more fixation so that the sample resemble a strip (see figure 1).

Figure 1: The Samples Resemble Strips

Staining Solution Preparation

A standard solution of tea was prepared so that five tea bags of a commercial brand (Ahmad tea company; tea bags / London; England.) was boiled in 500 milliliters of distilled water for 4 minutes after beginning of boiling and allowed to cool at room temperature (about 30º C).

The solution was replaced four times daily 6 hours each to prevent the precipitation and change in concentration. Cans of Pepsi cola were used at the room temperature (about 30º C); they were replaced twice daily to prevent the precipitation.

Baseline Color Measurements

The color was assessed using a spectrophotometer with xenon lamp as light source, according to Commission Internationale de l’Eclairage (translated as the International Commission on Illumination) CIE 1976 L*a*b’* color space system.

After numbering the specimens of each subgroup from 1 to 4 for tea and 1 to 4 for Pepsi cola by the marker pencil which couldn’t be removed by the solutions, they were incubated in distilled water in glass container at 37°C for 24 hours using incubator, baseline measurements was done to measure the light reflection of each specimen by spectrophotometer at visible wavelengths started from 400-700nm at 10nm intervals so for each specimen, thirty one value of light reflection were obtained [11] (see figure 2).

Figure 2: The Sample in the Spectrophotometer (uv-1800 SHIMADZU / Japan)

The result converted to CIE color system, (MATLAB 8 software, R2012b, 2012/ USA) was used to obtain the values for X, Y and Z obtained.

The CIE system uses three-dimensional colorimetric measurements: L* values correspond to the brightness of a color, a* values to the red-green content, and b*values to the yellow-blue content [12]. Then the L*, a* and b* were calculated by the following formula:

$$L* = 116(Y/Y0)^{1/3} - 16$$

$$a* = 500\,[\,(X/Xo)^{1/3} - (Y/Yo)^{1/3}\,]$$

$$b* = 200\,[\,(Y/Yo)^{1/3} - (Z/Zo)^{1/3}\,]$$

Measurement of the Color Change after Immersion in the Staining Solutions

The samples were placed in a glass container with the prepared staining solutions (tea and Pepsi cola), then incubated in the incubator at 37º C.

Color measurements were repeated after 7 days (T1), 14 days (T2), and 21 days (T3) of immersion in the solution; the solutions was replaced four times daily at each six hours.

Before each measurement, samples were removed from the solution and rinsed with distilled water for 5 minutes. Excess water on the surfaces was removed with tissue papers, and the samples were allowed to dry. Then the L*, a*and b* values of each specimen after immersion in treatment solutions were measured. The color difference between baseline measurement and measurement after immersion in solution as follows:

Δ L* = L2 _ L1

Δ a * = a 2 – a1

Δ b* = b2 – b1

Then the total color dereferences Δ E* for each specimen (distance between the 2 point in color space) were calculated by following equation:

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

The Δ E* of each subgroup was compared with others, to distinguish which type of coating material was more unstable in color and which staining solution cause more color change in aesthetic archwires.

To relate the amount of color change (ΔE*) to a clinical environment, the data were converted to National Bureau of Standards (NBS) units [13] as the following:

NBS units = Δ E* × 0.92

The definitions of color changes quantified by NBS units were used. These values were suggested by Koksal and Dikbas [14].

Statistical Analysis

1. Descriptive statistics including mean, standard deviation, maximum, minimum, and standard error.
2. Inferential statistics: including: One way analysis of variance (ANOVA) to test any statistically significant difference among the light reflection of groups and least significant difference (LSD) to test any statistically significant differences between each two subgroups when ANOVA showed a statistical significant difference within the same group. Significance for all statistical tests was predetermined at $P \leq 0.05$.

RESULTS

Table 3 shows the total color difference (**ΔL*, Δa*, Δb***) of the aesthetic archwires after 21 days of immersion in the staining solution. And Table4 shows the total color difference (ΔE*) of the aesthetic archwires after 21 days of immersion in the staining solution.

Both solutions (tea and Pepsi cola) caused color change in variable degree for all companies; the tea caused a large amount of color change than Pepsi cola, with highly significant change for all companies, while Pepsi cola caused significant change.

Hubit Company has the highest ΔE* after immersion in tea and Pepsi cola (Table 5); Orthotechnology company has the lowest ΔE* after immersion in Pepsi cola (Table 6). The amount of color change increased with time, but the great amount of change occurs in the first week then the staining progress in slower rate.

Table 3: Descriptive Statistics of ΔL*, Δa*, Δb* Values of the Four Companies and for Both Staining Solution (Tea and Pepsi Cola) after All Time Interval

Subgroup		Descriptive statistics											
		ΔL*				Δa*				Δb*			
		mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max
Tea	1	-13.56	2.563	-18.31	-9.305	2.164	0.445	-1.57	5.382	1.190	0.37	-6.53	5.28
	2	-16.53	2.924	-22.15	-12.924	1.555	0.533	-0.30	4.162	3.062	0.908	-0.83	6.37
	3	-17.83	1.347	-20.70	-16.211	-7.556	1.451	-8.75	-3.163	33.14	5.436	17.09	36.8
	4	-9.817	0.263	-16.95	-4.976	-0.029	0.008	-1.80	10494	1.056	0. 62	-2.06	7.76
Pepsi cola	1	-6.578	1.273	-8.471	-4.523	0.014	0.005	-0.85	1.364	0.721	0.087	-2.74	-2.74
	2	-7.832	2.873	-11.76	-2.045	0.774	0.025	0.164	1.698	-1.00	0.944	-3.05	-0.13
	3	-11.93	0.843	-13.00	-10.598	-0.233	0.031	-0.91	0.509	-1.54	0.050	-4.02	0.51
	4	0.855	0.137	-3.958	3.365	-1.251	0.015	-2.79	-0.004	2.163	0.153	-2.79	5.04

1: Dany Company 2: G&H Company 3: Hubit Company 4: Orthotechnology Company

Table 4: Descriptive Statistics of ΔE* Values of the Four companies and for Both Staining Solution (Tea and Pepsi Cola) after All Time Interval

Subgroup		Descriptive statistics ΔE* Mean	SD	Min.	Max.
Tea	1	14.056	2.986	9.383	19.751
	2	19.461	3.261	15.74	25.689
	3	39.687	4.244	27.297	42.899
	4	17.225	4.218	3.618	19.214
Pepsi cola	1	6.847	1.301	4.966	8.891
	2	9.898	1.947	6.247	13.303
	3	11.983	0.882	10.6	13.176
	4	3.256	0.737	2.119	4.608

Table 5: ANOVA Test Results for ΔE* Values for All Time Interval of DANY Company after Immersion in Pepsi Cola and Tea

Media	F-test	P-value	Sig
Tea	18.685	P<0.01	HS
Pepsi	8.960	0.01	S

Table 6: ANOVA Test Results for ΔE* Values for All Time Interval of Orthotechnology Company after Immersion in Pepsi Cola and Tea

Media	F-test	P-value	Sig
Tea	2.818	0.049	S
Pepsi	13.394	P<0.01	HS

DISCUSSION

Color changes were characterized by using the CIE L*a*b* color space. The CIE L*a*b* color space is currently one of the most popular and widely used systems of color measurement, and it is well suited for the determination of small color differences [15].

When compared the L*, a* and b* values of each company, the results found that means of L* values of all companies were decrease after immersion in both treatment solutions (ΔL* negative), because all of the specimens became darker after immersion in solutions, except for the Orthotechnology company after immersion on Pepsi cola which had ΔL* positive; When compared ΔE* of all the companies , we found that the highest change on color occurred at the end of the 3rd week , which means that it increased with time , but the greater change from the basic measurement occur on the 1st week, then the change in color progress in slower rate.

The present study shows that there are differences in the amount of color change of the difference aesthetic archwires from different companies under the same circumstances; this may be related to the chemical and physical composition of the aesthetic archwires which need further investigations to each company to discover out the cause of this variation [16-18].

The difference between the two staining solution (tea and Pepsi cola) is related to the composition of these solution. There is difference in the caffeine content between the two solutions, each 8 oz. (237 ml) of Black tea contain about 14-70 mg of caffeine while each 12 oz. (355 ml) of Pepsi cola contain about just 32-39 mg of caffeine[19,20]. The Pepsi cola contain also carbonated water (soda), Phosphoric acid, citric acid that may have some cleaning action, while the tea contain some precipitation from the tea leaves that will increase the staining effect [21-23].

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