Color Stability of Different Aesthetic Arch-wires after Immersion into Different Types of Mouthwashes (*In Vitro* Study)

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ABSTRAC

Background: Because of the demands for aesthetic orthodontic appliances have increased, aesthetic archwires have been widely used to meet patient's aesthetic needs. The color stability of aesthetic archwires is clinically important, any staining or discoloration will affect patient's acceptance and satisfaction. This study was designed to evaluate the color stability of different types of aesthetic archwires after immersion into different types of mouth washes.

Materials and methods: Four brands of nickel titanium coated aesthetic arch wires: Epoxy coated (Orthotechnology and G&H) and Teflon coated (Dany and Hubit) were evaluated after 1 week, 3 weeks and 6 weeks of immersion into two types of mouthwashes (Listerine with alcohol and Listerine without alcohol). Color change measurements were performed by using spectrophotometer VITA Easyshade Compact according to the commission Internationale de l'Eclairage L*a*b* color space system.

Results: The results of this study showed that there were highly significant differences in color change values among all brands of aesthetic archwires at various immersion media. On the other hand, a significant difference was found between Dany and Orthotechnology aesthetic archwires at 1 week immersion in distilled water. Listerine with alcohol mouthwash produced more color changes of aesthetic archwires and color change value increases with the time of immersion.

Conclusions: All brands of aesthetic archwires showed different degrees of color changes but most of these changes were not visible or clinically acceptable.

Key words: Color stability, aesthetic archwires, mouthwash. **(J Bagh Coll Dentistry 2017; 29(3):100-105)**

INTRODUCTION

Aesthetic, is one of major concerns during orthodontic treatment. The great demand for better aesthetics has led manufacturers to develop appliances which combine both acceptable aesthetics for the patient and adequate technical performance for the clinician. There are many aesthetic brackets and archwires in the markets when compared to mid-1990s [(1-3)].

Most of the orthodontic appliance components are metallic and silver in color. By the introduction of aesthetic brackets made of ceramic or composite, which become more popular, the aesthetic problem is partially solved, but the archwires are still made of metals such as titanium molybdenum alloy, nickel-titanium or stainless steel. Lately, coated metallic and fiber-reinforced archwires have been introduced to overcome this aesthetic problem. Fiber-reinforced arch wires are experimental and not universally commercial available, there are good anticipations from them for the future [(2,4,5)].

Materials used in archwire coatings are colored polymers or inorganic materials like polytetrafluoroethylene (Teflon), epoxy-resin, parylene-polymer, synthetic fluoride resins or less commonly palladium coverings to produce aesthetic archwires which simulate the color of teeth [(2,6)].

The color stability of aesthetic archwires is clinically important during orthodontic treatment. Ideally, the color of aesthetic archwires should match that of natural teeth and aesthetic brackets, but the color of natural teeth varies according to color measurement protocol, race, age and gender [(3,4)].

However, some authors have suggested that the color of coated archwires tends to change over time and the coating splits during use in the mouth exposing the underlying metal [(7)].

There are internal and external causes of discoloration of aesthetic arch wires. External discoloration may be caused by food dyes and colored mouth rinses, the type of coating material and its surface roughness play important roles in the extent of the discoloration. The amount of color change can be influenced by a number of factors, such as oral hygiene and water absorption [(8)].

This study was designed to evaluate the color stability of different types of aesthetic archwires after immersion into different types of mouth washes.

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MATERIALS AND METHODS

The Samples Preparation

The samples consisted of maxillary nickel titanium coated aesthetic archwires (0.018 *0.025 inch) with different coating materials and from different companies, they were: Epoxy coated (Orthotechnology Company / U.S.A. and G & H Company/ U.S.A.) and Teflon coated (Dany Company/Korea and Hubit Company/Korea).

Thirty six samples (nine samples from each Company) were prepared; each sample was made by cutting the preformed archwires into two halves, then putting ten halves of the aesthetic archwires segments together and uniting their free ends firstly by the light cure composite resin (Fig. 1), because it set quickly so it becomes easier to use the ethyl cyanoacrylate (super glue) to get more fixation, therefore; the sample resembles a strip (Fig. 2) [9,10]. The ethyl cyanoacrylate can tolerate the humidity so the samples stay as strips in the mouthwashes during the testing time. The coating surface of each wire segment was facing into the same direction so that the color could be measured properly.

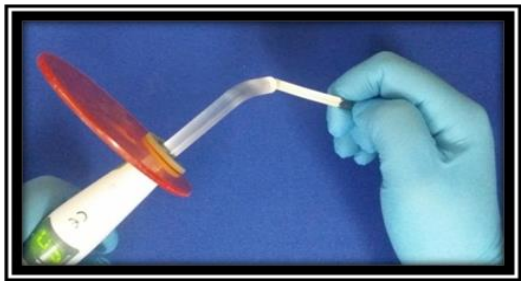

Fig. 1: Uniting the ten halves of the coated archwires segments together by light cure composite resin

Fig. 2: Sample from each Company resembles a strip

The Samples Grouping

The samples were grouped according to different time intervals which are: 1 week, 3 weeks and 6 weeks. For each time interval each group contains four strips, one strip from each Company as follow:

- Distilled water as a control group
- Listerine with alcohol
- Listerine without alcohol

} (4 strips; 1 strip from each company)

Listerine Mouthwashes Preparation

Two types of Listerine mouth washes (Listerine with alcohol and Listerine without alcohol Johnson & Johnson, UK.) used in this study were ready made solution. Equal amounts of mouth washes (500ml) were poured in covered containers to be ready for the designed procedure.

Color Measurements

The color measurement of each sample was performed by using a spectrophotometer VITA Easyshade Compact (VITA Zahnfabrik, Bad Sackingen, Germany) (Fig. 3).

Fig. 3: Spectrophotometer VITA Easyshade Compact

After numbering the samples of each Company from 1 to 4; 1 for Dany Company, 2 for Hubit Company, 3 for Orthotechnology Company and 4 for G&H Company by permanent marker that couldn't be removed by the mouth washes, they were incubated in distilled water at 37°C for 24 hours, baseline measurements (T0) were done. Then, the samples were divided into three main groups according to the immersion media (distilled water as a control media, Listerine with alcohol and Listerine without alcohol) and immersed in separate containers for 30 seconds twice daily, according to the manufacturer's instructions. During immersion, the samples were incubated at 37°C. After that the samples were stored in distilled water in the incubator at 37°C which is the temperature of the human body. Color change measurements were calculated after 1 week (T1), 3 weeks (T2), and 6 weeks (T3).

Before each color measurement, the samples were removed from the mouthwashes and rinsed with distilled water for 5 minutes. Excess water was removed by tissue papers and the samples were allowed to dry [4]. The samples were fixed and stabilized on white card boards [11]. Before performing the color measurements, the

spectrophotometer VITA Easyshade Compact was adjusted and calibrated according to the manufacturer's instructions and it was hold by a special holder and keep the tip of it perpendicular and in contact with archwires surface using ruler as a guide (Fig. 4) [5,11].

Fig. 4: The tip of VITA Easyshade Compact was perpendicular and in contact with archwires surface

The color measurements were taken from twelve reference points which located at different distances from the beginning of the coating material and these points were recognized by permanent marker at the posterior surface of the sample. Five measurements of each reference point were performed and the average was calculated [4,5,9].

Color changes were characterized using the Commission Internationale de l'Eclairage L*a*b* color space system (CIE L*a*b*), it depends on the following coordinates: **L*** describes lightness with values from 0 (black) to 100 (white), **a*** describes the red/green coordinate, with **+a*** indicating red and **-a*** indicating green and **b*** describes the yellow/blue coordinate, with **+b*** indicating yellow and **-b*** indicating blue [4,12-14].

Total color change **Δ E*** value was measured by this equation: **ΔE* = (ΔL*2 + Δa*2 + Δb*2)1/2** [4,14], where **ΔL*, Δa*** and **Δb*** are differences in L*, a* and b* values between baseline measurement (**T0**) and measurement after immersion at each time interval (**T1, T2, T3)** as follows:

Δ L* = L2 _ L1
Δ a * = a 2 – a1
Δ b* = b2 – b1

Then relate the **ΔE*** values to the clinical environment by converting the data to National Bureau of Standards **(NBS)** units [9,14,15] as follow:
NBS units = Δ E* × 0.92

Statistical Analyses

Data were collected and analyzed using SPSS (statistical package of social science) software version 19.The following statistics were used:

A- Descriptive Statistics: including mean, standard deviation (S.D.), minimum (Min.) and maximum (Max.) values.

B- Inferential Statistics: including:

1. One-way ANOVA test: was used to compare the ΔE* value (color change) among the different media and wire brands.
2. Tukey's honestly significant difference test (HSD): was performed to test any statistically significant difference in ΔE* value (color change) between any two groups.

In the statistical evaluation, the following levels of significance were used as follow:

NS Non-significant p>0.05
S Significant 0.05≥p>0.01
HS Highly significant p≤0.01

RESULTS

Table (1) showed total color changes (**ΔE*** values) and National Bureau of Standards **(NBS)** units of the aesthetic archwires at different time intervals of immersion in various media.

It was found that Hubit aesthetic archwires were the least color stable while Orthotechnology aesthetic archwires were the most color stable.

Listerine with alcohol caused more color changes of aesthetic archwires than Listerine without alcohol and color change value increases with the time of immersion.

Although all tested aesthetic archwires showed color changes among all immersion media at different time intervals but not all these color changes are clinically important. From clinical point of view, color changes can be expressed according to **ΔE*** values and **NBS** units, there were color changes not appreciable by the human eye **(Δ E* < l, trace and slight color change)** While clinically acceptable color changes which appreciable by skillful operator **(3.3 > Δ E* > l, slight and noticeable color change)**. But clinically unacceptable color changes which appreciable by non-skilled persons **(Δ E* > 3.3, appreciable color change)** [9,14-16].

Table (2) and (3) showed ANOVA test and Tukey HSD test results. It was found that there were highly significant differences in color changes (**ΔE*** values) among all aesthetic archwires brands in all immersion media at different time intervals.

On the other hand, a significant difference was found between Dany and Orthotechnology aesthetic archwires at 1 week immersion in distilled water.

Table 1: Descriptive statistics of ΔE* values and National Bureau of Standards (NBS) units of aesthetic arch wires in various immersion media at differenttime intervals.

Companies	Media	Duration	N	Mean	S.D.	Min.	Max.	NBS unit	Color change
Dany	Distilled water	1 week	12	0.141	0.002	0.138	0.146	0.12972	Trace
		3 weeks	12	0.273	0.003	0.268	0.277	0.25116	Trace
		6 weeks	12	0.286	0.001	0.284	0.289	0.26312	Trace
	Listerine with alcohol	1 week	12	0.539	0.004	0.534	0.546	0.49588	Trace
		3 weeks	12	1.014	0.008	1.010	1.040	0.93288	Slight
		6 weeks	12	1.536	0.002	1.532	1.539	1.41312	Slight
	Listerine without alcohol	1 week	12	0.323	0.003	0.320	0.329	0.29716	Trace
		3 weeks	12	0.494	0.002	0.490	0.498	0.45448	Trace
		6 weeks	12	0.896	0.002	0.892	0.899	0.82432	Slight
Hubit	Distilled water	1 week	12	0.342	0.003	0.338	0.347	0.31464	Trace
		3 weeks	12	0.697	0.002	0.693	0.699	0.64124	Slight
		6 weeks	12	0.726	0.004	0.719	0.730	0.66792	Slight
	Listerine with alcohol	1 week	12	1.396	0.004	1.389	1.399	1.28432	Slight
		3 weeks	12	2.132	0.002	2.128	2.135	1.96144	Noticeable
		6 weeks	12	3.358	0.002	3.354	3.360	3.08936	Appreciable
	Listerine without alcohol	1 week	12	0.852	0.002	0.849	0.856	0.78384	Slight
		3 weeks	12	1.244	0.003	1.240	1.249	1.14448	Slight
		6 weeks	12	2.266	0.003	2.260	2.270	2.08472	Noticeable
Ortho technology	Distilled water	1 week	12	0.123	0.003	0.118	0.127	0.11316	Trace
		3 weeks	12	0.213	0.002	0.210	0.217	0.19596	Trace
		6 weeks	12	0.253	0.038	0.200	0.300	0.23276	Trace
	Listerine with alcohol	1 week	12	0.637	0.003	0.630	0.643	0.58604	Slight
		3 weeks	12	1.065	0.031	1.010	1.100	0.9798	Slight
		6 weeks	12	1.804	0.002	1.801	1.808	1.65968	Noticeable
	Listerine without alcohol	1 week	12	0.242	0.002	0.238	0.246	0.22264	Trace
		3 weeks	12	0.341	0.003	0.337	0.346	0.31372	Trace
		6 weeks	12	0.748	0.005	0.740	0.755	0.68816	Slight
G&H	Distilled water	1 week	12	0.313	0.029	0.280	0.380	0.28796	Trace
		3 weeks	12	0.456	0.004	0.450	0.461	0.41952	Trace
		6 weeks	12	0.491	0.003	0.488	0.496	0.45172	Trace
	Listerine with alcohol	1 week	12	1.310	0.054	1.200	1.390	1.2052	Slight
		3 weeks	12	1.841	0.004	1.836	1.850	1.69372	Noticeable
		6 weeks	12	2.882	0.003	2.879	2.887	2.65144	Noticeable
	Listerine without alcohol	1 week	12	0.703	0.003	0.700	0.710	0.64676	Slight
		3 weeks	12	0.813	0.003	0.810	0.818	0.74796	Slight
		6 weeks	12	1.246	0.004	1.240	1.252	1.14632	Slight

Table 2: ANOVA test and Tukey HSD test results of aesthetic arch wires and the effect of aesthetic arch wires brand.

Duration	Media	F-test	p-value	Tukey HSD test					
				Dany vs. Hubit	Dany vs. Orthotec	Dany vs. G&H	Hubit vs. Orthotec	Hubit vs. G&H	Orthotec vs. G&H
1 week	Distilled water	722.576	0.000(HS)	0.000(HS)	0.017(S)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
	Listerine with alcohol	1007032.162	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
	Listerine without alcohol	131963.910	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
3 weeks	Distilled water	72137.972	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
	Listerine with alcohol	722497.476	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
	Listerine without alcohol	262314.062	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
6 weeks	Distilled water	1580.672	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
	Listerine with alcohol	1125902.728	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
	Listerine without alcohol	417999.534	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)

Table 3: ANOVA test and Tukey HSD test results of aesthetic arch wires and the effect of various immersion media.

Companies	Duration	F-test	p-value	Tukey HSD test		
				Control vs. Lis A	Control vs. Lis W	Lis A vs. Lis W
Dany	1 week	3103525.149	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
	3 weeks	1585764.170	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
	6 weeks	7821098.786	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
Hubit	1 week	3718981.182	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
	3 weeks	5787882.082	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
	6 weeks	6349430.423	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
Ortho technology	1 week	723610.659	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
	3 weeks	64977.088	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
	6 weeks	87695.362	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
G&H	1 week	17658.179	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
	3 weeks	1882589.490	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
	6 weeks	5123299.815	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)

***Lis. A (Listerine with alcohol), *Lis. W (Listerine without alcohol).**

DISCUSSION

The color stability of aesthetic archwires is an important factor in the success of an aesthetic orthodontic treatment, but the color of these archwires tends to change overtime [7].

The sensitivity of the human eye in observing small color differences is limited and the interpretation of visual color comparisons is subjective. Instrumental measurements minimize the subjective interpretation of visual color comparisons, therefore; spectrophotometer is used instead of visual evaluation [4,5].

Recently, VITA Easyshade Compact is one of the latest spectrophotometers which available for clinical use. This instrument is small, wireless, easy to handle and allow an improved understanding of color perception and its correlation with clinical aspects [13].

Color changes were characterized using the Commission Internationale de l'Eclairage L*a*b* color space system (CIE L*a*b*) which is one of the most popular and universally used system for dentistry and many authors used this system to evaluate the perceptibility of color differences [4,12-14].

Many authors had used **ΔE*** values to evaluate the perceptibility of color differences [18,19]. However, it is noteworthy that the criteria for perceptibility used by each author were somewhat different. To overcome these differences and disagreements in the criteria, the National Bureau of Standards **(NBS)** system is frequently used to define the degree of color difference **(Δ E*** value**)** according to the clinical significance [9,14,15].

Water absorption, absorption or adsorption of colorants from mouthwashes may be the causes of color changes of aesthetic archwires that is in agreement with other findings [17-19]. Moreover, color changes of aesthetic archwires may be related to presence of alcohol and pH level of the tested mouthwashes, it was found that low pH level and high alcohol concentration of mouthwashes may affect the surface integrity by softening the coating material and cause discoloration, this comes in agreement with other researches [20,21].

In conclusion; although all brands of aesthetic archwires showed color changes at variable degrees but most of these changes were not visible or clinically acceptable.

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الخلاصة

الخلفية: نتيجة الطلب المتزايد على أجهزة تقويم الأسنان التجميلية ,أُستُخدمت أسلاك التقويم التجميليةعلى نطاق واسع تلبيةً لمطالب المرضى. إن الأستقرار اللوني لأسلاك التقويم التجميلية مهم سريرياً, فأي تصبغ أوتغير لوني سيؤثر على رضا وقناعة المريض. صممت هذه الدراسة لتقييم الاستقراراللوني لأنواع مختلفة من أسلاك التقويم التجميلية بعد غمرها في أنواع مختلفة من غسولات الفم.

الموادوالطرق: تم تقييم أربع ماركات من أسلاك النيكل تيتانيوم التجميلية المغلفة: المغلفة بالأيبوكسي (Orthotechnology و G&H) والمغلفة بالتفلون (Dany وHubit) بعد أسبوع واحد وثلاثة أسابيع ثم ستة اسابيع من الغمر في نوعين من غسولات الفم (ليسترين مع الكحول و ليستيرين بدون كحول) وقد أجريت قياسات التغير اللوني بأستخدام جهاز فحص الطيف اللوني (VITA Easyshade Compact) وفقاً للمنظمة العالمية للأضاءة.

النتائج: لقد أظهرت نتائج هذه الدراسة وجود أختلافات معنوية كبيرة في قيم التغير اللوني بين جميع ماركات أسلاك التقويم التجميلية في مختلف بيئات الغمر.من الجانب الاخر, وُجِد أختلاف معنوي بين أسلاك التقويم التجميلية لشركة (Dany) وشركة (Orthotechnology) خلال فترة الغمر لأسبوع واحد في الماء المقطروقد أنتج غسول الفم ليستيرين مع الكحول تغيرات لونية أكثر لأسلاك التقويم التجميلية كما إن قيمة التغير اللوني تزداد بزيادة فترة الغمر.

الاستنتاجات: أظهرت جميع ماركات أسلاك التقويم التجميلية تغيرات لونية بدرجات مختلفة ولكن معظم هذه التغيرات كانت غير مرئية أو مقبولة سريرياً.

الكلمات المفتاحية: الأستقرار اللوني, أسلاك التقويم التجميلية ,غسول الفم.