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The Effect of Fluoridated and Non Fluoridated Mouth Washes on Color Stability of Different Aesthetic Arch Wires At Different Time Intervals (An in Vitro Study)

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Abstract

Background: The color stability of aesthetic arch wires is an important factor in the success of an aesthetic orthodontic treatment, but the color of these arch wires tends to change with time.This study was performed to assess the effect of two types of mouth washes on the color stability of different types of aesthetic arch wires at different time intervals.

Materials and methods: Four brands of nickel titanium coated aesthetic arch wires were used: epoxy coated (Orthotechnology and G&H) and Teflon coated (Dany and Hubit).Thirty six samples were prepared, each sample contains ten halves of the aesthetic arch wires. They were divided into three groups according to the immersion media (distilled water as a control media, Listerine with fluoride and Listerine without fluoride) and immersed for 30 seconds twice daily according to manufacturer's instructions to measure color change after 1 week, 3 weeks and 6 weeks by using spectrophotometer VITA Easyshade Compact according to Commission Internationale de l'Eclairage L*a*b* color space system.

Results: It was found that there were highly significant differences in color change values of aesthetic arch wires among all immersion media at different time intervals and color change value increases as the time of immersion increases.Additionally, Listerine with fluoride mouth wash caused higher color change values of aesthetic arch wires than Listerine without fluoride and Hubit aesthetic arch wires were the least color stable while Orthotechnology aesthetic arch wires were the most color stable.

Conclusions: We can conclude that the daily use of Listerine mouth washes could affect on the color stability of aesthetic arch wires. Although all tested aesthetic arch wires revealed color changes at variable degrees but some of these changes were not visible and the others were clinically acceptable while the remaining were clinically unacceptable.

Key words: Color stability, aesthetic arch wires, mouth wash, time interval.

الخلاصة

الخلفية:إن الأستقرار اللوني لأسلاك التقويم التجميلية عامل مهم في نجاح علاج تقويم الأسنان التجميلي لكن لون هذه الأسلاك يميل الى التغير مع مرور الوقت. تم تنفيذ هذه الدراسة لتقييم تأثير نوعين من غسولات الفم على الأستقرار اللوني لأنواع مختلفة من أسلاك التقويم التجميلية لفترات زمنية مختلفة.

المواد والطرق:أستخدمت أربع ماركات من أسلاك النيكل تيتانيوم التجميلية المغلفة: المغلفة بالأيبوكسي (Orthotechnology و G&H) والمغلفة بالتفلون (Dany وHubit). تم تحضير ستة وثلاثين شريط كل شريط يحتوي على عشرة أنصاف من أسلاك التقويم التجميلية. قُسِمت الى ثلاثة مجاميع حسب بيئة الغمر (الماء المقطر، ليستيرين مع الفلورايد وليستيرين بدون الفلورايد) و غُمرت لمدة ثلاثين ثانية مرتين يومياً وفقاً لتعليمات الشركة المصنعة لغرض قياس مقدار التغير اللوني بعد أسبوع واحد وثلاثة أسابيع ثم ستة أسابيع بأستخدام جهاز فحص الطيف اللوني (VITA Easyshade Compact) وفقاً للمنظمة العالمية للأضاءة.

النتائج: لقد وجدت أختلافات معنوية كبيرة في قيم التغير اللوني لأسلاك التقويم التجميلية بين جميع بيئات الغمر لفترات زمنية مختلفة كما إن قيمة التغير اللوني تزداد بزيادة فترة الغمر.أضافة الى ذلك غسول الفم ليستيرين مع الفلورايد سبب تغيراً لونياً بقيم أكبر لأسلاك

التقويم التجميلية مقارنة مع ليستيرين بدون الفلورايد وكانت أسلاك التقويم التجميلية لشركة (Hubit) الأقل أستقراراً لونياً في حين كانت أسلاك التقويم التجميلية لشركة (Orthotechnology) الأكثر أستقراراً لونياً.

الاستنتاجات: نستطيع أن نستنتج إن الأستعمال اليومي لغسول الفم ليستيرين يمكن أن يؤثر على الأستقرار اللوني لأسلاك التقويم التجميلية.على الرغم من إن جميع أسلاك التقويم التجميلية المُختبرة أظهرت تغيرات لونية بدرجات مختلفة ولكن بعض هذه التغيرات كانت غير مرئية وأخرى مقبولة سريرياً بينما المتبقية كانت غير مقبولة سريرياً.

الكلمات المفتاحية: الأستقرار اللوني، أسلاك التقويم التجميلية ،غسول الفم، فترة زمنية.

Introduction

There is an increasing demand for better aesthetics during orthodontic treatment and this demand has led to the enhancement of appliances that provide proper clinical work and good aesthetics **(Russell, 2005; Kaphoor & Sundareswaran, 2012; Aksakalli & Malkoc, 2013)**.Most of conventional arch wires have unaesthetic metallic and silvery appearances.A number of alternatives has been investigated to create aesthetic arch wires that would allow efficient aesthetic orthodontic treatment **(Burstone *et al.*, 2011; da Silva *et al.*, 2013; Akin *et al.*, 2014).**

Coated metallic and fiber-reinforced composite arch wires are currently the existing solutions to this aesthetic problem.There are different materials used in arch wires coatings such as polytetrafluoroethylene (Teflon), epoxy-resin, parylene-polymer, synthetic fluoride resins or palladium coverings **(Elayyan *et al.*, 2010; Arango *et al.*, 2013).**

Like other aesthetic orthodontic products, aesthetic arch wires can be discolored due to extrinsic and intrinsic causes.Colored mouth washes and nutriment dyes can produce extrinsic discoloration of aesthetic arch wires.Water absorption, oral hygiene, type and surface roughness of the coating material play important roles in the extent of color change **(Faltermeier *et al.*, 2008).**

Several researchers found that the coating material cleaves and cracks showing the underlying metal wire and it's color alters over time during usage inside the mouth **(Lim *et al.*, 1994; Kusy, 2002; Elayyan *et al.*, 2010).** It was reported that aestheic arch wires show observable color changes after 21 days in staining solutions and they are liable to chewing forces and the enzymatic activity of the oral cavity **(da Silva *et al.*, 2013).**

Materials And Methods

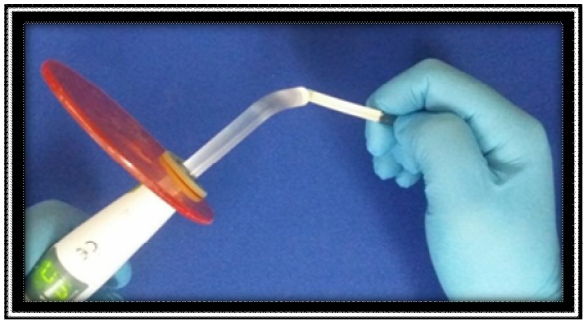
The Samples Preparation:

Four brands of aesthetic coated arch wires were assessed. The brand, cross section size, coating type and composition are shown in (Table 1), as described by the manufacturers.

(Table 1): Characteristics of the aesthetic arch wires used in the study.

Brand	Cross section size	Coating type	Composition
Dany Company / Korea	0.018 *0.025 inch	Teflon	nickel titanium
Hubit company / Korea	0.018 *0.025 inch	Teflon	nickel titanium
Orthotechnology company/ U.S.A.	0.018 *0.025 inch	Epoxy	nickel titanium
G &H Wire company / U.S.A.	0.018 *0.025 inch	Epoxy	nickel titanium

Thirty six samples (nine samples from each company) were prepared; each sample was made by cutting the aesthetic arch wires into two halves, then putting ten halves of the aesthetic arch wires segments together and joining their free ends initially by the light cure composit resin **(Fig 1)**, because it sets quickly so it becomes simpler to use super glue (ethyl cyanoacrylate) to get more fixation.Therefore the sample resembles a strip **(Fig 2) (Mohammed, 2013; Noori & Ghaib, 2016).**The ethyl cyanoacrylate can tolerate the humidity so the samples stay as strips in the mouth washes during the testing time.



(Fig 1): Joining the ten halves of the aesthetic arch wires segments together by light cure composit resin.

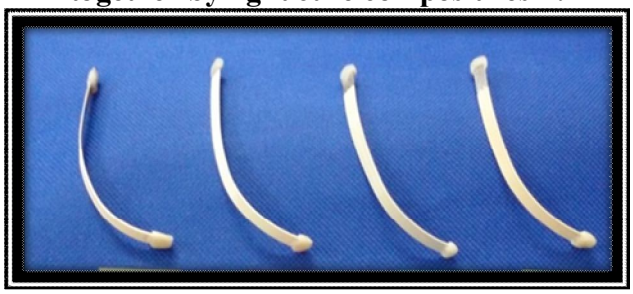


Fig (2) : Sample from each company resembles a strip

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 fluoride
- Listerine without fluoride

} (4 strips)(1 strip from each company).

Listerine Mouth Washes Preparation

Two types of Listerine mouth washes (Listerine with fluoride and Listerine without fluoride) **(Fig 3)** that 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.

Fig (3) : A- Listerine with fluoride mouth wash.
B- Listerine without fluoride mouth wash.

Color Measurements

The color measurement of each sample was performed by using a spectrophotometer VITA Easyshade Compact (VITA Zahnfabrik, Bad Sackingen, Germany) **(Fig 4)**.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 fluoride and Listerine without fluoride) and immersed in separate containers at their side so the labial surface doesn't touch the container 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 mouth washes and rinsed in distilled water for 5 minutes. Excess water was removed by tissue papers and the samples were allowed to dry.The samples were fixed and stabilized on white cardboards **(Razavi *et al.,* 2016)**.Before performing the color measurements, the spectrophotometer VITA Easyshade Compact was adjusted and calibrated according to the manufacturer's instructions and it was holden by a special holder and keep the tip of it perpendicular and in contact with arch wires surface using ruler as a guide **(Fig 5) (Akin *et al.,* 2014, Razavi *et al.,* 2016).**

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 **(da Silva *et al.,* 2013; Mohammed, 2013; Akin *et al.,* 2014).**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 values: **L*** describes the lightness value from 0 (black) to 100 (white), **a*** describes the color saturation from red to green, where positive value indicating red and negative value indicating green and **b*** describes the color saturation from yellow to blue, where positive value indicating yellow and negative value indicating blue **(Commission Internationale de I'Ecleirage (CIE), 2004; Corciolani, 2009; da Silva *et al.,* 2013; Inami *et al.,* 2015).**

Fig (4) : Spectrophotometer VITA Easyshade Compact.

Fig (5) : The tip of VITA Easyshade Compact was perpendicular and in contact with arch wires surface.

Total color change **Δ E*** value was measured by this equation: **ΔE* = (ΔL*2 + Δa*2 + Δb*2)1/2 (da Silva *et al.,* 2013; Inami *et al.,* 2015).** ,where **ΔL*, Δa*** and **Δb*** are differences in L*, a* and b* values between baseline color measurement (**T0**) and color 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 convert the **ΔE*** values to National Bureau of Standards **(NBS)** units to define the degree of color change according to clinical significance as follow:

NBS units = Δ E* × 0.92

Statistical Analysis

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

B-Inferential Statistics: including:

1. **One-way ANOVA test:** was used to compare the **ΔE*** value (color change) among different media and time intervals.
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 $0.05\geq p>0.01$
HS Highly significant $p\leq 0.01$

Results

(Table 2) showed total color changes (**ΔE*** values) and National Bureau of Standards **(NBS)** units of the aesthetic arch wires at different time intervals of immersion in various media.It was found that Hubit aesthetic arch wires were the least color stable while Orthotechnology aesthetic arch wires were the most color stable.Listerine with fluoride mouth wash caused higher **ΔE*** values than Listerine without fluoride and **ΔE*** value increases as the time interval increases.Moreover, most of color changes of the aesthetic arch wires that caused by Listerine with fluoride mouth wash were clinically unacceptable (appreciable).

(Table 3) and (Table 4) showed **(ANOVA)** test and **Tukey (HSD)** test results of aesthetic arch wires and the effect of the immersion media and immersion time.It was found that there were highly significant differences in color changes (**ΔE*** values) among all immersion media at all time intervals.

(Table 2): Descriptive statistics of ΔE* values and National Bureau of Standards (NBS) units of aesthetic arch wires in various immersion media at different time 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 fluoride	1 week	12	3.135	0.002	3.132	3.139	2.8842	Noticeable
		3 weeks	12	4.049	0.003	4.045	4.055	3.72508	Appreciable
		6 weeks	12	5.237	0.004	5.230	5.245	4.81804	Appreciable
	Listerine without fluoride	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 fluoride	1 week	12	3.880	0.003	3.876	3.885	3.5696	Appreciable
		3 weeks	12	4.738	0.003	4.732	4.744	4.35896	Appreciable
		6 weeks	12	6.436	0.003	6.430	6.440	5.92112	Appreciable
	Listerine without fluoride	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 fluoride	1 week	12	1.793	0.003	1.788	1.799	1.64956	Noticeable
		3 weeks	12	2.713	0.003	2.710	2.718	2.49596	Noticeable
		6 weeks	12	3.928	0.003	3.923	3.932	3.61376	Appreciable
	Listerine without fluoride	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 fluoride	1 week	12	2.985	0.004	2.980	2.990	2.7462	Noticeable
		3 weeks	12	3.819	0.004	3.812	3.826	3.51348	Appreciable
		6 weeks	12	5.038	0.003	5.034	5.042	4.63496	Appreciable
	Listerine without fluoride	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 3): (ANOVA) test and (HSD) test results of aesthetic arch wires and the effect of the immersion media.

Companies	Duration	F-test	p-value	Tukey HSD test		
				Control vs. Lis. F	Control vs. Lis. W	Lis. F 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. F (Listerine with fluoride).**
***Lis. W (Listerine without fluoride).**

(Table 4): (ANOVA) test and (HSD) test results of aesthetic arch wires and the effect of the immersion time.

Companies	Media	F-test	p-value	Tukey HSD test		
				1 week- 3 weeks	1 week- 6 weeks	3 weeks- 6 weeks
Dany	distilled water	14923.819	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
	Listerine with fluoride	103797.349	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
	Listerine without fluoride	163978.345	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
Hubit	distilled water	59444.933	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
	Listerine with fluoride	1570444.775	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
	Listerine without fluoride	804261.935	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
Ortho technology	distilled water	111.160	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
	Listerine with fluoride	12914.706	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
	Listerine without fluoride	71993.494	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
G&H	distilled water	369.337	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
	Listerine with fluoride	7845.413	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)
	Listerine without fluoride	83866.095	0.000(HS)	0.000(HS)	0.000(HS)	0.000(HS)

Discussion

The aesthetic appearance of orthodontic appliances is important to clinicians and patients.For ideal aesthetic form, the color of aesthetic arch wires must be identical to the color of aesthetic brackets and natural teeth, but the color of natural teeth differs in accordance with age, race, gender and color investigation protocols **(Aksakalli & Malkoc, 2013; da Silva *et al.*, 2013; Akin *et al.*, 2014).**

Since instrumental measurements eliminate the subjective interpretation of visual color comparison, therefore spectrophotometers are used instead of visual evaluation.The Vita Easyshade is one of the most modern spectrophotometers accessible for clinical applications.This instrument is small, wireless , easy to handle and permits an enhanced

comprehension of color recognition and its relationship with clinical aspects **(Corciolani, 2009).**

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 common and universally used system for dentistry and many authors used this system to assess the perceptibility of color changes **(Commission Internationale de I'Ecleirage (CIE) , 2004; Corciolani, 2009; da Silva *et al.,* 2013; Inami *et al.,* 2015).**

Color changes can be expressed according to **ΔE*** values and **NBS** units **(da Silva *et al.,* 2013; Filho *et al.,* 2013; Mohammed, 2013; de Oliveira *et al.,* 2014; Inami *et al.,* 2015).**Although all tested aesthetic arch wires 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, 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)** .

These color differences of aesthetic arch wires may be attributed to water absorption, absorption or adsorption of colorants from mouth washes, that is in agreement with **(Noie *et al.,* 1995; Al-Attar, 2014; Lepri *et al.,* 2014)**.Also, presence of fluoride ions in mouth wash may dissolve the surface layer, increasing surface roughness and consequently cause discoloration, this is in agreement with **(Papagiannoulis *et al.,* 1997; Butler *et al.,* 2004; Kirubagaran, 2016).**

Conclusions

The daily use of Listerine mouth washes could affect on the color stability of aesthetic arch wires.Listerine with fluoride mouth wash caused higher color change values than Listerine without fluoride.Hubit aesthetic arch wires were the least color stable while Orthotechnology aesthetic arch wires were the most color stable.

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