Original Article

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Laboratory Evaluation of Fluoride Varnish Effect on Ionomer Glass Color Using a Digital Camera and Spectrophotometer

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ABSTRACT

BACKGROUND AND OBJECTIVE: The impact of external factors on color of ionomer glass as a restorative material is important due to its beauty. The aim of this study was to evaluate discoloration of conventional and resin-modified ionomer glass, after the application of fluoride varnish.

METHODS: In this study, 16 samples of each ionomer glass Chemfil Superior (C) and (F) Fuji II LC were prepared. Then fluoride varnish Dura shield (Sultan, USA) was used on samples (Cf, Ff). The color of each sample was measured using a spectrophotometer (Gretage Macbeth, Color-eye7000A) and digital camera (Sony Cyber-shot DSC N1) before and after the application of fluoride varnish. Obtained data from camera was converted to color space Lab CIE by MATLAB software. Discoloration (ΔE) of each sample was calculated in spectrophotometer and digital camera and statistical analysis was performed.

FINDINGS: Using spectrophotometer ΔE in Cf and Ff groups was obtained 4.44 and 5.8, respectively, but with a digital camera was 2.37 and 4.21, respectively in the same group. The application of fluoride varnish in the evaluation of a spectrophotometer and a digital camera resulted in a statistical significant color change in samples (respectively $p<0.001$ and $p=0.028$). In addition, the data showed a significant correlation in obtained results from spectrophotometer and digital camera ($p=0.045$ and $r=0.357$).

CONCLUSION: Based on the results of this study in evaluation by spectrophotometry, application of fluoride varnish (Dura shield) led to an apparent color change in both ionomer glass. According to the same results, digital camera for evaluation of color is relatively reliable.

KEY WORDS: *Ionomer Glass, Fluoride Varnish, Color, Spectrophotometry*.

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Introduction

For more than 20 years, fluoride varnish is being applied in Europe and Canada. The main reasons for the wide acceptance of fluoride varnish are the easy application, safety, convenience and acceptability for the patient. Also, the amount of fluoride ions absorbed by the tooth structure increases compared to other methods. There are different types of fluoride varnish on the market that can contain either sodium fluoride or difluorosilane (1-3).

Sodium fluoride varnishes can have several side effects such as discoloration of the teeth and restorative materials. In general, internal factors such as chemical-physical reactions in deeper parts of material and external factors such as absorption of color materials lead to discoloration (4-6).

Dura shield is containing 5 wt% sodium fluoride (containing 2.26 wt% fluoride). Regarding external factors, composition and size of filler particles in addition to surface smoothness influences external staining and relative susceptibility of dental materials. There are different methods for evaluating color, among them spectrophotometer is a standard device (2). If the color change of samples is higher than the threshold 3.3, it is sensible and unacceptable. Since the spectrophotometer method is relatively expensive, studies have been conducted to evaluate the color by using the digital camera but comparing these methods in evaluating color have been reported conflicting results (7-9). Caglar and colleagues examined the reliability of the digital camera in color measurement, reported a significant relationship between L and b values of camera with the colorimeter, but not in the parameter of a (10). On the other hand, Yamanel and colleagues compared the composite colors using the colorimeter and digital camera reported that if the distance of the object from camera, camera settings and lighting conditions are suitable, the digital camera can be used in color evaluation (11).

Therefore, because one of the main reasons in the replacement of tooth-colored materials such as glass ionomer is color changes (2), the aim of this study was to determine the influence of fluoride varnish on the color stabilityof glass ionomer using a digital camera and spectrophotometer.

Methods

Methods: This experimental study was performed on 32 samples of glass ionomer. Half of the samples (n=16) of conventional glass ionomer chemfil and the other half (16=n) of resin-modified glass ionomer Fuji II LC were prepared. The chemical composition of the used materials are listed in table 1.

Preparation of the samples: 1- Chemfil(C): After mixing powder and liquid according to the manufacturer's instructions, 16 samples were prepared by using a cusbic mold (2mm depth×13 mm length ×13 mm width). and then a glass lamella were placed on the top surface of the samples and remained for 8 minutes until setting was completed.

2-Fuji IILC-(F): powder and liquid were mixed according to the manufacturer's instructions and 16 samples were prepared in the same mold of Group 1. Samples were cured with intensity of 750 mw/cm2 of Astralis 7 (Ivoclar) for 40 seconds. All samples in Group C and F were placed in normal saline solution for 48 hours.

Fluoride varnish application: Dura shield fluoride varnish was applied on the t of half (8) of the Chemfil (Cf) samples and half (8) of the Fuji II LC (Ff) samples by a specific applicator and then was dried by the air. After 5 minutes, samples were placed in normal saline as group 3 and 4.

Photoaging: All samples were subjected under photo aging (Xeno test 150s, USA) with wave length of 300-800 nm, the light intensity of 765 w/m2 and daily radiation of 66mj/m2 for 98 hours in 37˚c (12).

Color measurement

Digital camera: the outer surface of all samples from groups C, Cf, F and Ff were under photography after drying by a digital camera (sony cyber-shot - DSC N1 8.1 MP - optical zoom 3X - Japan). All photos were emitted in a completely dark room, and with two D65 lamps, at a fixed position and at a constant distance of 30 cm from the samples with two opposite direction. A fixed gray screen was used in the back of samples. The camera was fixed on the base and its distance from the sample, and the light source and gray matrix was similar during the experiments (10).

The taken images by digital camera were saved in the computer and the color of sample were determined by using MATLAB software and Lab values of outer surface of the glass ionomer samples were measured according to the CIE system. To use MATLAB software for evaluation of color, the camera was standardized with 238 standard samples of munsel color atlas and a relationship was formed between the camera data (color stimulators of RGB camera) and color stimulators of standard samples (XYZ or Lab) as matrix. Any new standardized photos from the camera by the matrix and device-independent color values photographed samples became similar to samples obtained from spectrophotometer. Comparing the color difference (ΔE) between groups C and Cf, F and Cf were determined by the following formula:

$$\Delta E=[(\Delta L)^2+(\Delta a)^2+(\Delta b)^2]^{½}$$

Spectrophotometer: the color of outer surface of all samples from C, Cf, F and Ff groups was determined by a spectrophotometer (Gretag Macbeth, color-eye70000 A, USA) and their ΔE were obtained similar to digital camera group based on formula ΔE=[(ΔL)2+(Δa)2+(Δb)2]½. Data were analyzed using SPSS statistical software and Anova, T-Test and Paired T-Test and Pearson correlation coefficient were used and $p<0.05$ was considered significant.

Results

Average change of color of samples tested using ΔE Spectrophotometer in Cf, C, Ff and F was 4.44, 2.17, 5.80 and 1.76, respectively (Fig 1), but with a ΔE digital camera in the same group was 2.73, 1.92, 4.21 and 2.90, respectively (Fig 2).

Color change (ΔE) in 4 groups were analyzed separately and obtained results in the spectrophotometers and digital camera showed significant difference between groups. ($p<0.001$ and $p=0.028$, respectively). In addition, obtained data from digital camera and spectrophotometer showed a significant correlation ($p=0.045$ and $r=0.357$). Average of components L, a and b of the glass ionomer samples obtained from digital camera are presented in Table 1

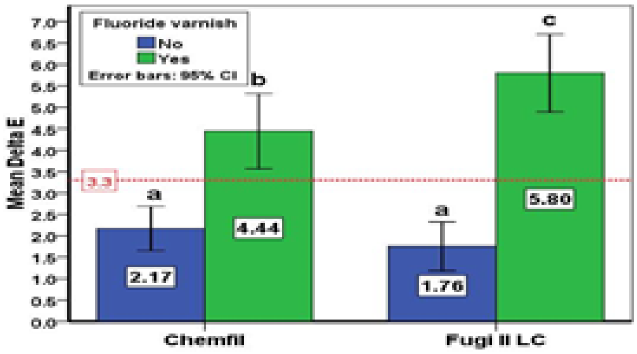

Figure 1. Mean and standard deviation of ΔE (discoloration) of glass ionomer in the application of fluoride varnish using a spectrophotometer

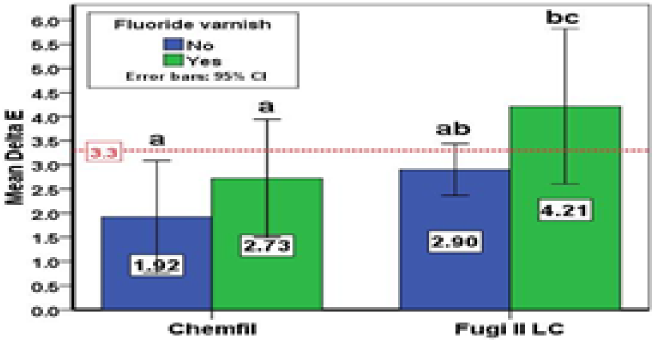

Figure 2. Mean and standard deviation of ΔE (discoloration)) of glass ionomer in the application of fluoride varnish using a digital camera

Table 1. The mean and standard deviation of L, a and b components of glass ionomer samples using a digital camera

Group		Cf Mean±SD	C Mean±SD	Ff Mean±SD	F Mean±SD	P-value
L	Pre	89.54±1.22	89.96±1.14	90.49±0.54	90.67±0.72	0.095
	Post	90.03±0.89	90.44±0.42	88.73±0.66	89.42±0.54	<0.001
	Pvalue	0.391	0.37	<0.001	0.005	–
a	Pre	7.62±0.45	7.58±0.53	7.2±0.72	7.29±0.76	<0.001
	Post	7.54±0.57	7.54±0.75	7.6±0.58	6.88±0.7	<0.001
	Pvalue	0.003	0.138	<0.001	0.002	-
b	Pre	7.97±0.94	7.27±0.91	4.37±1.04	3.84±0.98	0.472
	Post	5.76±1.4	6.37±1.26	2.39±0.92	7.48±1.62	<0.046
	Pvalue	0.74	0.901	0.221	0.278	-

Cf: chemfil Group with the application of fluoride varnish. C: chemfil Group without the use of fluoride varnish. Ff: fuji II LC Group with fluoride varnish application . F: fuji II LC Group without the use of fluoride varnish.

Discussion

In this study, both types of Chemfil and Fuji II LC glass ionomer in the application of Dura shield fluoride varnish showed a clear color change after evaluation by spectrophotometer. (ΔE> 3.3) data obtained from the spectrophotometer and digital cameras had also a

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significant correlation. Both conventional and resin-modified glass ionomer in this test after the application of Dura shield fluoride varnish and after the Photoaging (Xeno Test 150 S) during 98 hours showed a clear color change in a spectrophotometer assessment which among the CIE color parameters, factor b *, have shown statistically significant changes in a positive direction.

These results are consistent with results of Autio-Gold et al. They examined the effect of fluoride varnish on Value and Hue oftwo types of composite and glass ionomer using a colorimeter (Minolta chroma-meter) to evaluate discoloration of Fluor protector and Dura flor fluoride varnish (13). Debner and colleagues in their study concluded that fluoride varnish can be lead to clear discoloration in restorative material which was consistent with our study (14). Autio-Gold et al evaluated the effect of the application of 4 types of fluoride varnishes; Duraflor, Duraphat, Cavity Shield and Fluor Protector on color change of two resin composites and a glass ionomer cement and concluded that Duraphat can cause detectable color changes in restoration, which has been clinically acceptable.

In this study, the colorimeter (Minolta chroma-meter) was used to assess color. In addition, this study showed more color variations in glass ionomer than composites due to its hydrophilic properties and more superficial damage. Other causes of glass ionomer staining can be noted to fine pores and cracks in the glass ionomer allowing to the dyes to penetrate into the materials (2). In the study of Salama and colleagues, the effect of Dura flor and Cavity shield varnish fluoride on restorative materials, glass ionomer (Fuji IX GP), Compomer (2000 F) and composite (Filtek TM Flow) was investigated and the Profilometer and SEM was used to investigate roughness of material surface.

It concluded that surface roughness of restorative material increased by application of fluoride varnish, which can cause surface discoloration (15). As mentioned at the beginning of the study, evaluation of color was done using spectrophotometer and a digital camera. For each sample, in order to maintain a fixed position during the shooting with a digital camera angles were considered which was similar to shooting conditions in the study of Guan and colleagues. In this study, a digital camera at a constant distance from the sample and two light source with a distance of 30 cm from the samples were used (8). It was also reflected light from the two light sources that was D65 light. D65 is a standard light source determined by CIE and has introduced as a light source (10). In this study, a gray cardboard were set up around the shooting environment to completely limit and then color evaluation was performed by the MATLAB software. Cal and his colleagues in 2004 investigated in color evaluation of 3 shade guides by using digital techniques.

They took photos from three shade guide by using a digital camera with a fixed distance from each sample. In their study the digital images were captured from all the samples once at 11 a.m. (daylight) and again in studio environment. They concluded when the environment is constant, the digital technique and Photoshop color analysis program can be used for image analysis.

But in this study the use of digital cameras has not compared with the standard method (16). In the study of Guan and his colleagues, MATLAB software was used for tooth color measurement based on L * a * b * system. in this study the digital camera (Kodak Nikon DCS 410) was used and light sources were 2 fluorescent tubes with natural light and ultra-violet fluorescent tubes and two samples (extracted teeth) were at a distance of 25 cm from the light sources with the 45 degrees(8). Along with the study of Guan and colleagues which considered the use of digital cameras as an acceptable method in measuring color changes, in our study obtained data from the camera showed a significant relationship with the spectrophotometer. In the study of Cal and colleagues a digital camera (Olympus-camediac 2500-L) was used and the camera was placed on the base as vertical to color guides and concluded that the data from the camera in L * a * and b * parameters had a significant relationship with spectrophotometer, but this relationship was not acceptable for L * parameter (17).

The data obtained in our study showed a significant correlation of the digital camera and spectrophotometer. Caglar and colleagues in 2009 investigated the reliability of the digital camera in color measurement. In this study, two types of composite color guide and ceramic color guide were used as example. The study consists of four fluorescent light sources placed as vertically with a distance of 15 cm from the samples, respectively. They used camera (Fuji S20 pro, Fuji film, Tokyo, Japan) in an Auto white balance condition equipped with a CCD sensor in their study. L * and b * values obtained from the camera had a significant relationship with the colorimetric but about a * this was not acceptable. The results of this study showed that digital camera in case of correct application and precision adjustment of camera and use of suitable light source could be considered as an appropriate method(10). Tung and colleagues in his study used a digital camera with a flash to investigate the color of their color guides. In this study, 15 ceramic disc with the different color guides were provided and a digital camera (Nicon D1, Tokyo, Japan) equipped with a CCD sensor as Auto white balance (AWB) and Custom White Balance (CWB) were placed as a perpendicular status than the color guides and LED was used as the light source. This study showed a significant relationship in CWB status of camera compared with the data from the spectrophotometer. They concluded that the performance of digital camera to check the color are depended on the light sources and set up of camera (7). In this study, results showed that the digital camera is rather reliable method for evaluating color. Given the mixed results of different studies, it is suggested that the assessment of color should be done in different lighting conditions with other cameras compared with spectrophotometer.

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