BALKAN JOURNAL OF DENTAL MEDICINE

BaSS

ISSN 2335-0245

The Influence of Topical Fluoride Application on Colour Stability of Aesthetic Fluoride-Releasing Restorative Materials

SUMMARY

*Fluoride-releasing restorative materials are often combined with topical fluoride application products in order to enhance fluoride effects. The purpose of this study was to determine the colour stability of 3 aesthetic fluoride-releasing restorative materials after application of 2 topical fluoride products. 15 disc shaped specimens were prepared for each restorative material and were divided into 3 groups. Topical fluorides were applied onto the specimens according to the manufacturer's instructions. The procedure of fluoride application was repeated twice. Colour properties of all specimens were evaluated at baseline and 48 hours after topical fluoride application. Colour analysis was performed using the spectrophotometer and CIE L*a*b* method. 3 consecutive readings were recorded for each specimen and L*, a*, b* parameters and a mean number of readings were calculated.*

According to the results, topical fluoride application products caused changes of colour properties in the examined materials, but these changes were clinically acceptable with the ΔE value being below 3.3. In general, it can be concluded that fluoride application products can be safely used on the restorative materials without causing clinically significant colour changes.*

Keywords: Restorative materials, fluoride-releasing; Colour stability

E. Kalampalikis, E.A. Koulaouzidou, E. Koliniotou-Koumpia, M. Helvatjoglu-Antoniades

Aristotle University, Department of Dental Tissues Pathology and Therapeutic Operative Dentistry, Thessaloniki, Greece

ORIGINAL PAPER (OP)
Balk J Dent Med, 2014; 18:24-28

Introduction

Aesthetic restorative materials releasing fluoride are widely used in dentistry because they have the advantages of caries prevention, inhibition of tooth demineralization and enhancing the remineralizing potential[1,2]. They are mainly used for fillings in children and in elderly patients with high caries risk. Conventional glass ionomers, resin modified glass ionomers, poly-acid modified composite resins (compomers), composite resins releasing fluoride and giomers (composites with Pre-Reacted Glass ionomer fillers - PRG)[3] are referred as aesthetic fluoride-releasing restorative materials[4]. Often, fluoride released from restorative materials is not enough for caries prevention and additional topical application of fluoride-containing products is desirable[1,5]. Topical fluorides provide additional protection against dental caries and they are also used in cervical sensitivity treatment. Fluoride topical application products are applied on both tooth structure and restorative materials surface and thus they may affect the colour of aesthetic restorations.

The products available for topical fluoridation include gels, varnishes and foams. Fluoride gels are divided into those with acidulated phosphate fluorides (APF), which contain 1.23% or 12,300 ppm of fluoride ions, and those with 2% sodium fluoride (NaF), which contains 0.90% or 9,050 ppm of fluoride ions. Fluoride varnishes usually contain 5% sodium fluoride, which is equivalent to 2.26% or 22,600 ppm of fluoride ions[6].

While tooth-coloured materials provide successful aesthetic dental restorations, unacceptable colour match or staining are major reasons to replace anterior fillings[7]. Intrinsic factors due to physicochemical reactions in the

deeper portions of the restoration or extrinsic factors, such as absorption or accumulation of stains, can cause discoloration[8]. The development of colorimetry has facilitated study related to colour stability, enabling one to identify particular colour science parameters[9].

Colour measurement in dentistry is usually represented by the CIE (1976) L*a* and b* colour formula. L* refers to the lightness or whiteness coordinate, with a value range from 100 (perfect white) to zero (perfect black). The parameters a* and b* are chromaticity, or colour coordinates on the red-green axis and the yellow-blue axis, respectively. Positive a* values signify red and negative a* values represent green; similarly, positive b* values signify the yellow axis and negative b* values represent the blue axis[10].

The CIE L*a*b* can be used to calculate the colour difference between 2 objects by ΔE* value, which is given by the formula: $\Delta E^*_{ab} = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$, where ΔL*, Δa* and Δb* are the differences between the parameters of 2 samples. Spectrophotometers can be used to evaluate in vitro colour changes and represent a subjective interpretation of visual-colour comparison[9]. However, not all colour differences are visually perceptible. Studies in the dental literature have reported that when ΔE* values range between ΔE*>1 and ΔE*<3.3, the colour difference is not perceived by the human sense of sight under ideal lighting conditions and therefore is not clinically significant, whereas ΔE*> 3.3 has been reported as clinically significant and unacceptable[11-14].

The purpose of this study was to determine the effect of 2 topical fluoride application products on colour stability of 3 aesthetic fluoride-releasing restorative materials. The null hypothesis tested was that topical fluoride application does not affect the colour of the materials.

Materials and Method

The restorative materials tested were the following (Tab. 1): (1) a conventional glass ionomer cement (encapsulated) - KetacFil Plus Aplicap (3M ESPE, St.Paul, MN, USA); (2) a resin modified glass ionomer cement, Fuji II LC Capsules (GC America, Alsip, IL, USA); and (3) a giomer (resin composite containing surface Pre-Reacted Glass ionomer fillers - PRG, having the ability to constantly bind and release fluoride[3]), Beautifil II (Shofu Inc, Kyoto, Japan). The topical fluoride application products were: (1) Duraphat varnish - 5% Sodium Fluoride (Colgate Oral Pharmaceuticals, New York, NY), recommended application time 4 minutes, and (2) C-Care gel - 1,23% APF - acidulated phosphate fluoride, pH 3-4 (Dental Line Ltd, Piraeus, Greece), recommended application time 60 seconds.

Table 1. Names and characteristics of the tested fluoride-releasing restorative materials

Restorative material	Manufacturer	Type	Shade
KetacFil Plus Aplicap	3M ESPE, St. Paul, MN, USA	Conventional glass ionomer cement, encapsulated	A3
Fuji II LC Capsules	GC America, Alsip, IL, USA	Resin modified glass ionomer cement	A3
Beautifil II	Shofu Inc., Kyoto, Japan	Giomer containing Surface Pre-Reacted Glass ionomer fillers (PRG)	A3

45 disc shaped specimens (15 of each restorative material), 10mm in diameter and 2mm in height were prepared in split Teflon moulds, pressed between transparent plastic strips and glass slabs, to obtain a uniformly smooth specimen surface. The materials were manipulated and polymerized according to the manufacturers' instructions. A Satelec Mini LED, (KaVo Dental GmbH, wavelength 420 - 480 mm, output 1.100 mW/cm^2) was used to polymerize the light cured materials (GC Fuji II LC and Beautifil II). The specimens made of chemically polymerized glass ionomer cement (KetacFil Plus) were left for recommended period of time (7 minutes from the start of mixing) to complete chemical polymerization. After that, the upper side of all specimens was polished using silicon carbide and aluminium oxide polishing disks (Super-Snap Singles Standard, Shofu Inc, Kyoto, Japan), starting with coarse discs and ending with extra fine discs. After polishing, the specimens were stored in distilled water for 24 hours.

The specimens of each material were divided into 3 groups (5 specimens in each group). Fluoride varnish Duraphat was applied to the specimens of the first group for 4 minutes, C-Care gel was applied to the specimens of the second group for 60 seconds, while the specimens of the third group were used as control and remained in distilled water during the whole duration of the experiment. After the recommended time, the specimens treated with fluoride applications were brushed and rinsed to completely remove fluoride products and afterwards they were immersed in distilled water for 48 hours. Then the fluoride application was repeated and the specimens were immersed in new distilled water for additional 48 hours. All procedures were performed by a single operator. Colour properties of all specimens, including control group, were evaluated 24 hours after manufacturing (baseline) and 48 hours after each topical fluoride application.

Colour analysis was performed using the scientific spectrophotometer Shimadzu UV-2401 PC Series Uv-VIS and the method CIE L*a*b*. The specimens were inserted

into the scientific spectrophotometer and using a black background 3 consecutive readings were taken from each specimen; L*, a* and b* parameters and a mean value of readings were calculated. Before each measurement the spectrophotometer was calibrated to a white standard, which consisted of a pressed powder tablet of barium sulphate according to the manufacturer's instructions.

The statistical analysis was performed with the minimum, maximum, median, mean and standard deviation. In addition, a 95% confidence interval was used. The control for adjusting the normal distribution was done with the Shapiro-Wilk test and the review for homogeneity of dispersions was made with Levene's test of equality of variances. The study of statistically significant difference between control specimens and specimens with application of fluoride preparations was done with the 2-sample parallel design with Mann-Whitney U test. The analysis was performed with the SPSS 16.0 software package (SPSS Inc., Chicago, IL, USA) and the level of statistical significance for all tests was set at $p<0.05$.

Results

The mean ΔE* values and standard deviations (SD) of all specimens of the examined materials, after the first and second fluoride application, are presented in table 2. Fuji II LC specimens showed the lowest ΔE* value (0.76 ± 0.31) after the first application of the Duraphat varnish, while the highest ΔE* value (3.00 ± 1.25) was recorded for KetacFil Plus specimens after the second application of Duraphat varnish. Statistically significant differences ($p<0.05$) of ΔE* values were found between control measurements and measurements after fluoride applications (Tab. 2).

Table 2. ΔE mean values (n=5) and standard deviation (SD) after 1st and 2nd application of the topical fluoride products*

Beautifil II		
	1st application ΔE* (SD)	2nd application ΔE* (SD)
Control	0.75 (0.54)	0.75 (0.59)
Duraphat	2.75 (0.86)*	2.16 (0.59)*
C-Care	0.99 (0.73)	1.74 (0.96)
Fuji II LC		
	1st application ΔE* (SD)	2nd application ΔE* (SD)
Control	0.26 (0.09)	0.34 (0.15)
Duraphat	0.76 (0.31)	0.86 (0.65)
C-Care	1.99 (1.06)	1.70 (0.97)
KetacFil Plus		
	1st application ΔE* (SD)	2nd application ΔE* (SD)
Control	1.04 (0.39)	1.26 (0.45)
Duraphat	1.73 (0.86)	3.00 (1.25)*
C-Care	1.94 (0.70)	2.86 (0.91)*

* statistically significant ($p<0.05$)

Discussion

The null hypothesis of the present study was rejected since the analysis of the results showed that application of both topical fluoride products on the restorative materials caused colour change, which varied according to the fluoride application product and the restorative material. ΔE* values ranged between the lowest 0.76 (after the first application of Duraphat varnish on Fuji II LC specimens) and the maximum 3.00, after the second application of Duraphat on KetacFil Plus specimens (Tab. 2).

As previously mentioned, colour difference values of $\Delta E^*<1$ are not visually perceptive. When values range between $\Delta E^*>1$ and $\Delta E^*<3.3$, the colour difference can not be perceived by the human sight even under ideal lighting conditions and, therefore, it is not clinically significant. On the other hand, value of $\Delta E^*>3.3$ is reported as clinically significant and unacceptable.[9-12] According to this, no clinically significant changes in the colour of the tested restorative materials were found in the present study after topical fluoride applications.

It may be pointed out though that the greatest colour difference was found in the specimens of KetacFil Plus (conventional glass ionomer) after the second application of Duraphat varnish (ΔE* = 3,0038 ± 1,2584), as well as after the second application of the C-Care gel (ΔE* = 2,8617 ± 0,9176). Taking into consideration standard deviations in above results, it could be assumed that the effect of both topical fluoride products in this specific filling material caused a colour change that might be visually perceptive and therefore may have clinical importance.

Statistically significant differences were found in change of colour of the samples after applying topical fluoride products as compared to the change of colour in the control group, in 4 occasions: the first and the second application of Duraphat on Beautifil II specimens, and the second application of Duraphat and C-Care on KetacFil Plus specimens. These occasions were in accordance with the greatest ΔE* values, confirming that there was a colour change indeed. Nevertheless, only in the case of KetacFil Plus the colour change might be clinically important.

Among the examined materials, the one that showed the maximum colour changes after topical fluoride application was the conventional glass ionomer cement KetacFil Plus, whereas the resin modified glass ionomer Fuji II LC showed the minimum colour changes. This could be attributed to the different chemical composition of the materials and, consequently, the different physicochemical properties. Staining by absorption is one of the extrinsic factors producing discoloration. The composition and size of the filler particles affect both surface smoothness and susceptibility for extrinsic staining[15]. Relative susceptibility of glass ionomer for staining could be attributed to the porosity of

glass particles[15]. Moreover, in the presence of water, conventional glass ionomers exhibit higher solubility compared to resin modified glass ionomers and giomer, resulting in faster degradation of the material' outer surface and, therefore, the increase of surface roughness despite the initial polishing of the material[15,16]. Furthermore, when conventional glass ionomers were exposed to acid attack, they exhibit even more erosion than in water and the ions of the matrix would be lost, resulting in formation of pores. The extent of this erosion depends on pH of the environment and begins when the pH reaches the value 4[17]. Topical fluoride products have low pH, and pH value of C-Care product ranges in between 3 and 4.

Resin modified glass ionomers and giomers are more resistant to corrosion by water, even under the influence of acidic fluoride applications due to the resin content in their composition[18,19]. Moreover, they exhibit lower surface roughness after initial polishing, which they retain longer than the conventional glass ionomers, resulting in lower affection by the pigments of topical fluoride applications[20].

Regarding the influence of 2 different fluoride application products on the colour of the examined materials, Duraphat varnish affected more the conventional glass ionomer KetacFil Plus, while C-Care had greater influence on colour change of resin modified glass ionomer - Fuji II LC. The colour of giomer Beautifil II was affected more by Duraphat during the first application, whereas by C-Care during the second application. The light amber colour of DURAPHAT varnish and its stickiness might explain the more intense effect on the less glossy and rougher surface of the conventional glass ionomer KetacFil Plus[21]. Regarding the effect of C-Care on giomer and resin modified glass ionomer cement, it has been reported that APF gel applications can cause adverse effects on resin composites, such as the increased surface roughness[22], and can influence their colour stability[23]. Nevertheless the differences of ΔE* values for both topical fluoride applications in the present study were negligible and did not appear to be clinically significant.

Our results are in agreement with the results of previous studies that examined the effect of topical fluoride applications on aesthetic restorative materials. Debner et al[12] examined the colour changes of Dyract AP (compomer), Fuji II LC (resin modified glass ionomer) and TPH Spectrum (composite resin) after application of 3 fluoride varnishes (Duraphat, Duraflor and FluorProtector). Their measurements were made by the CIE L*a*b* formula using a spectrophotometer. According to their results, Duraflor and Duraphat applications caused noticeable colour changes (ΔE*>3.3) in all the restorative materials after application and before brushing. After brushing they found that the materials did not appear to have noticeable changes in colour as in most cases ΔE* values were less than 3.3, except for the composite resin TPH Spectrum when Duraphat varnish was applied and ΔE* value was 5.4, which is a clinically significant colour change. However, when FluorProtector varnish was used, no effect on the colour of any restorative material was observed.

Autio-Gold et al[21] evaluated the colour stability of composite resins Z-100, Esthet-X and a conventional glass ionomer Fuji IX GP after application of fluoride varnishes Duraphat, Cavity Shield, Duraflor and Fluor Protector by the CIE L*a*b* formula. They found that Duraphat varnish caused significant changes in all the tested materials, with ΔE* ranging between values 1 and 3, changes that the authors considered to be clinically acceptable.

From the results of this study it can be concluded that fluoride applications can cause colour changes in aesthetic fluoride-releasing restorative materials, which can be recognized by special measurement techniques such as spectrophotometer, but not visually perceptible and clinically acceptable. Therefore, topical fluorides tested in this study can be safely used as far as the colour stability of tested fluoride-releasing restorative materials is concerned.

References

1. *Kidd EAM*. The use of diet analysis and advice in the management of dental caries in adult patiens. *Oper Dent*, 1995; 20:86-93.
2. *Stookey GK*. Caries prevention. *J Dent Educ*, 1998; 62:803-811.
3. *Ikemura K, Tay FR, Endo T, Pashley DH*. A review of chemical approach and ultramorphological studies on the development of fluoride-releasing dental adhesives comprising new Pre-Reacted Glass ionomer (PRG) fillers. *Dent Mater*, 2008; 27:315-339.
4. *Wiegand A, Buchalla W, Attin T*. Review on fluoride-releasing restorative materials - fluoride release and uptake characteristics, antibacterial activity and influence on caries formation. *Dent Mater*, 2007; 23:343-362.
5. *Kula K, Nelson S, Kula T, Thompson V*. In vitro effect of APF gel on the surface of composites with different filler particles. *J Prosthet Dent*, 1986; 56:161-169.
6. American Dental Association Council on Scientific Affairs. Professionally applied topical fluoride. Evidence-based clinical recommendations. *J Am Dent Assoc*, 2006; 137:1151-1159.
7. *Kroeze HJ, Plasschaert AJ, Van't Hof MA, Train GJ*. Prevalence and need for replacement of amalgam and composite restorations in Dutch adults. *J Dent Res*, 1990; 69(6):1270-1274.
8. *Horsted-Bindslev Ñ, Mjor IA*. Esthetic restoration in Modern Concepts. In: Operative Dentistry. Copenhagen: Munksgaard, 1988; pp 190-246.
9. *Dietschi D, Campanile G, Holz J, Meyer JM*. Comparison of the color stability of ten new-generation composites: An in vitro study. *Dental Materials*, 1994; 10(6):353-362.

10. *Broadbent DA*. A Critical Review of the Development of the CIE1931 RGB Color-Matching Functions. *Wiley Periodicals Inc*, 2003; 29(4):267-272.
11. *Iazzetti G, Burgess JO, Gardiner D, Ripps A*. Color stability of fluoride-containing restorative materials. *Oper Dent*, 2000; 25(6):520-525.
12. *Debner T, Warren DP, Powers JM*. Effects of fluoride varnish on color of esthetic restorative material. *J Esthet Dent*, 2000; 12(3):160-163.
13. *Johnston WM, Kao EC*. Assessment of appearance matched by visual observation and clinical colorimetry. *J Dent Res*, 1989; 68(5):819-822.
14. *Wee AG, Lindsey DT, Shroyer KM, Johnston WM*. Use of porcelain color discrimination test to evaluate color difference formulas. *J Prosthet Dent*, 2007; 98:101-109.
15. *Peutzfeldt A, Asmussen E*. Color stability of three composite resins used in the inlay/onlay technique. *Scand J Dent Res*, 1990; 98(3):257-260.
16. *Setchell DJ, Teo CK, Khun AT*. The relative solubilities of four modern glass ionomer cements. *Br Dent J*, 1985; 158(6):220-222.
17. *Kakaboura A, Vougiouklakis G*. Cements in Orthodontics. In: *Brantley WA, Eliades T*. Orthodontic Materials. Scientific and Clinical Aspects. Stuttgart: Thieme, 2001; pp 221-240.
18. *Sidhu SK, Watson TF, Anstice HM, Billington RW, Pearson GJ*. Moisture susceptibility of resin-modified glass-ionomer materials. *Quintessence Int*; 1995; 26(11):753-754.
19. *Swift EJ Jr, Pawlus MA, Vargas MA*. Shear bond strengths of resin-modified glass-ionomer restorative materials. *Oper Dent*, 1995; 20(4):138-143.
20. *Craig RG, Powers JM*. Restorative Dental Materials. 11th edition. St Louis: Mosby, Inc, 2002; pp 199-285, 594-634.
21. *Autio-Gold JT, Barrett AA*. Effect of fluoride varnishes on color stability of esthetic restorative materials. *Oper Dent*, 2004; 29(6):636-641.
22. *Soeno K, Matsumura H, Kawasaki K, Atsuta M*. Influence of acidulated phosphate fluoride agents on surface characteristics of composite restorative materials. *Am J Dent*, 2000; 13:297-300.
23. *Tanoue N, Soeno K, Kawasaki K, Atsuta M*. Influence of acidulated phosphate fluoride solution on color stability of indirect composites. *J Prosthet Dent*, 2004; 92:343-347.

Correspondence and requests for offprints to:
E. Kalampalikis
Dental School, Department of Operative Dentistry
Thessaloniki
Greece
E-mail: operdent@gmail.com