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Original Article

Evaluation of staining potential of 5% sodium fluoride varnish and coffee beverage on tooth-colored restorative materials: An *in vitro* study

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ABSTRACT

Objectives: The objective of this *in vitro* study was to evaluate and compare the staining potential of 5% sodium fluoride varnish and coffee beverage on the tooth-colored restorative materials.

Material and Methods: Standardized Class V cavities were prepared on the tooth surface on both buccal and lingual/palatal surfaces and were restored with Glass ionomer cement (GIC), resin-modified GIC (RMGIC), and resin composite. The control group (n = 7) of each restoration was stored in artificial saliva. The experimental groups (n = 7) of each of the restoratives were subjected to the application of 5% sodium fluoride and were analyzed for discoloration using the visual method. In the second part of the study, 5% NaF was applied on all the restorations, namely, GIC, RMGIC, and Resin Composite. The control groups of each (n = 7) were then stored in artificial saliva and the experimental groups of each (n = 7) were immersed in coffee. After the period of immersion, the control, as well as the experimental groups, were analyzed for staining using the visual method. Data obtained were statistically analyzed using the Chi-square test.

Results: All the experimental groups were stained up to a visually perceptive level (P = 0.029) when compared to the control group. However, the intergroup comparison of experimental groups was statistically non-significant. Furthermore, RMGIC showed better stain resistance with coffee after application of 5% NaF than GIC and resin composite, although it was not statistically significant.

Conclusion: 5% NaF application resulted in a shade change of all the restoratives tested in the study up to a visually perceptive level. The fluoride application did not significantly influence the staining potential of coffee in the restoratives tested.

Keywords: Sodium fluoride, Staining potential, Coffee, Glass ionomer cement, Resin modified Glass ionomer cement

INTRODUCTION

One of the main goals of aesthetic dentistry is to mimic teeth and design a smile that is pleasing to the human eye. The proper color match to the adjacent tooth is important not only in the initial period of service but also over a longer period.[1]

Glass ionomer cement (GIC), has been advocated for use because of various reasons, including its physical-chemical bonding to the tooth structure, acceptable aesthetic properties, biocompatibility, fluoride release, inhibition of bacterial acid metabolism, similar coefficients of thermal expansion to that of the tooth structure, and ease of clinical application.[2] In order

to improve the mechanical properties of conventional GIC, Resin Modified GIC (RMGIC) has been introduced, which contain hydrophilic monomers and polymers such as HEMA.[3] Properties of Resin Composite such as high aesthetics, conservative approach, adhesion to the tooth structure, and superior mechanical properties make it a good anterior restorative material. Although the quality of composite resin restorations has improved with the advent of new technologies in material science in recent years, discoloration of the composite resin material remains a major long-term clinical problem. The color stability of these restorative materials in a dynamic oral environment is an important criterion influencing its clinical longevity which continues as an inherent challenge to the material.[4]

Topical fluoride therapy has various clinical applications such as in the management of dentinal hypersensitivity,[5] caries control and prevention,[6] and fluoride recharge of appropriate restorations.[7] Various studies have been conducted on the staining potential of topical fluorides on several dental restorations and has been been documented in the literature.[8,9]

Profluorid® Varnish (VOCO, Germany) is a fluoride-containing dental desensitizing varnish used for dentinal hypersensitivity and is claimed to be highly effective. The manufacturer also claims that the product does not impair aesthetics or cause discoloration of the tooth. However, the staining potential of this product on the various dental restorations has not been evaluated to the best of our knowledge.

The objective of the present study was to evaluate the staining potential of 5% Sodium fluoride (VOCO Profluorid® Varnish) on GIC, RMGIC, and Resin Composite. The objective of the second part of the study was to evaluate the effect of 5% sodium fluoride (NaF) on the staining potential of coffee on the above-mentioned restorative materials.

MATERIAL AND METHODS

Sample size estimation

Sample size was calculated based on a study conducted by Lin and Huang titled: Staining potential of acidulated phosphate fluoride (APF) foam on dental restorations *in vitro*.

Sample size was calculated based on the comparison of staining rate on teeth/or the restorations of GIC and CR. Sample size was calculated using the following formula:

$n = (Z_{\alpha/2}+Z_{\beta})^{2*} (p_1(1-p_1)+p_2(1-p_2))/(p_1-p_2)^2$

$Z_{\alpha} = 1.96$

$Z_{\beta} = 0.67$ (75% power of the study)

p1 = 50%, (1-p1) =50%, p2 = 17.5%, (1-p2) =82.5%

N = 25.825 = 26.

42 intact extracted posterior human teeth were collected, debrided with an ultrasonic scaler, and were stored as per OSHA norms. The teeth with intact caries-free surfaces were selected for the study. The teeth were sectioned at the level of CEJ and the roots were discarded. Then the teeth were completely sectioned mesiodistally to obtain two halves (buccal and lingual) from one tooth.

Thus, 84 intact tooth surfaces were obtained to attain the total sample size.

Tooth preparation with cavity dimension of 4 mm (length mesiodistally) *3 mm (width occlusoapically) *2 mm (depth) was done on each intact tooth surface.

28 samples each were restored with GIC, RMGIC, and Resin Composite, respectively, in the cavities prepared.

Evaluation of staining potential of sodium fluoride

42 samples were randomly chosen for this part of the study. They were divided into six groups.

The GIC group: The prepared cavities were filled with the GIC (GC Gold Label Universal restorative, Japan) of shade A2. The polishing of the restorations was done after 24 hours with TR-25EF polishing diamond abrasives (Mani Inc, Japan).

The RMGIC group: The prepared cavities were filled with RMGIC (GC Gold Label Light cure Universal Restorative, Japan) of shade A2 and were cured with a curing unit (3M ESPE Elipar, United States) for 30 s. The restorations were then polished with TR-25EF polishing diamond abrasives (Mani Inc, Japan).

The Resin Composite group: The prepared cavities were etched with an etchant (3M ESPE Scotchbond Multipurpose Etchant, United States) for 20 s and the etchant was washed off for 30 s and blot dried. The adhesive (Te-Econom bond, Ivoclar Vivadent, India) was applied and was cured for 15 seconds. The resin composite material (Te-Econom Plus, Ivoclar Vivadent, India) of shade A2 was used to fill the cavities and was contoured with a mylar strip and photo cured for 30 s. The restorations were then polished with TR-25EF polishing diamond abrasives (Mani Inc., Japan).

42 of the restored specimens were divided into control and the experimental groups, which are tabulated in the [Table 1].

All the control group samples were stored in artificial saliva. While the experimental group samples were subjected to a fluoride application procedure and later stored in artificial saliva.

The fluoride application

Each specimen of the experimental groups was subjected to the application of 5% NaF (VOCO Profluorid® Varnish). The first layer of varnish was applied with an applicator tip

provided by the manufacturer. After automatic drying of the first layer, a second coat was applied likewise. After the fluoride application, the specimens were stored in artificial saliva. At the end of the day, each specimen was cleaned using a toothbrush (20 strokes in mesio-distal as well as occluso-apical direction each) to simulate circumoral musculature, the tongue, and the tooth brushing. The fluoride application process was repeated for a total of 2 consecutive days to simulate the repeated application a patient might undergo during the desensitization procedure or as a caries control measure. All the control and experimental groups were subjected to thermocycling in a water bath between 5°C and 55°C for 500 cycles. The dwell time in each bath was 20 s, and the transfer time between the two baths was 5 s.

On the 3rd day, each specimen of the experimental group was compared with a specimen of the corresponding control group for visible shade change or marginal staining by three different blinded examiners who were calibrated earlier. The scoring criteria was introduced by Lin and Huang,[8] in terms of yes or no for visible staining on the surface of the restoration or the margins. The score 1 was given for Yes (staining present) and score 0 for No (staining absent) for the documentation and statistical analysis.

Evaluation of staining potential of coffee

The remaining 42 samples which were already restored with the test materials were taken for further experiments according to the groupings tabulated in [Table 2].

The control groups (n = 7): The control groups (Groups 1–3) were subjected to coffee application. The coffee solution was made by dissolving 2.2 g of instant coffee powder (Bru instant) into 250 mL of boiling water along with constant stirring. All the samples were immersed in hot coffee for 10 min. After this period, the tooth specimens were cleaned using a tooth brush with 20 strokes in both directions. This procedure was followed for 3 consecutive days and coffee was prepared fresh for each day. Later these specimens were stored in artificial saliva.

The experimental groups (n = 7): The experimental groups (Groups 4–6) were first subjected to fluoride application with the same protocols as in the first part of the study. Following fluoride application, these were immersed in hot coffee for 10 min and same protocol was followed as in control group. All the control and experimental groups were subjected to thermocycling in water bath between 5°C and 55°C for 500 cycles. The dwell time in each bath was 20 s, and the transfer time between the two baths was 5 s.

On the 4th day, each specimen of the experimental group was compared with a specimen of the corresponding control group for visible shade change or marginal staining by three different examiners who were blinded. The scoring criteria were the same as that described earlier.

Table 1: Groupings in the first part of the study.

Group A	GIC control group
Group B	RMGIC control group
Group C	Composite control group
Group D	GIC fluoride group
Group E	RMGIC fluoride group
Group F	Composite fluoride group

Table 2: Groupings in the second part of the study.

Group 1	GIC fluoride control group
Group 2	RMGIC fluoride control group
Group 3	Composite fluoride control group
Group 4	GIC fluoride and coffee group
Group 5	RMGIC fluoride and coffee group
Group 6	Composite fluoride and coffee group

RESULTS

2 GIC and 4 each of RMGIC and Resin Composite samples were stained after the application of 5% NaF varnish, that is, 28.60% of GIC and 57.10% each of RMGIC and Resin Composite were stained. Hence, all the experimental groups were stained up to visually perceptive level with a Chi-square test value of 9.001 and with a significance of P = 0.029, which is represented in [Graph 1].

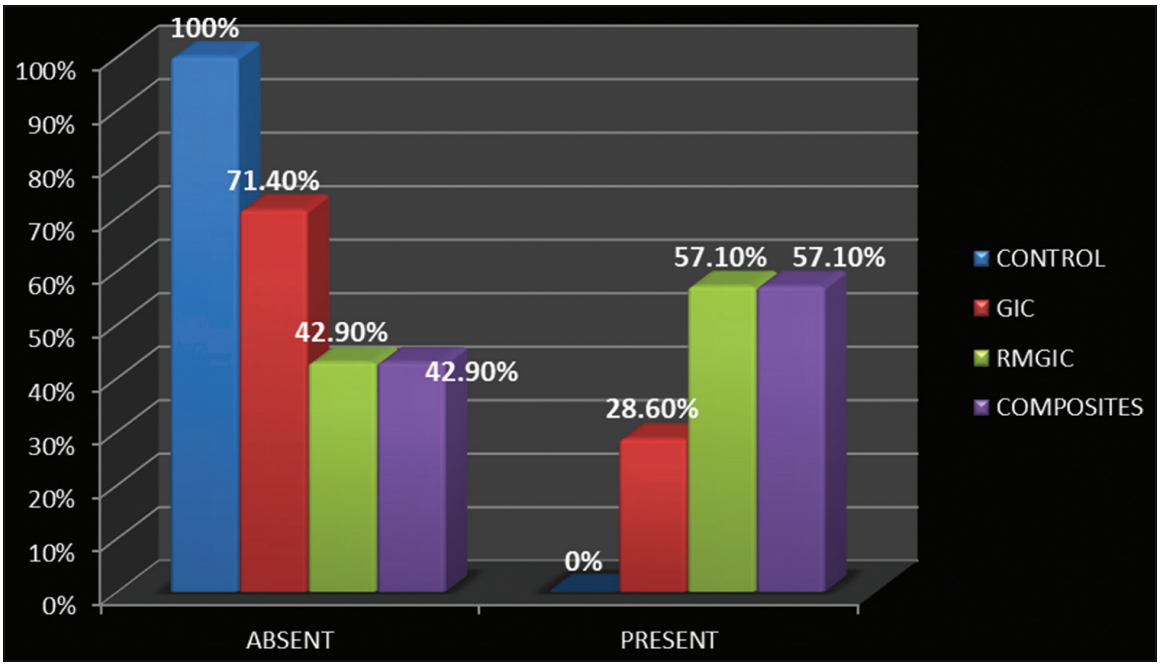
However, intergroup comparison of experimental groups gave a Chi-square value of 1.167 and it was statistically non-significant (P = 0.592) which is tabulated in [Table 3].

In the second part of the study, in the control group (only coffee), the staining rates were as follows: GIC-71.4%, RMGIC - 0%, and Composite - 71.4%. The staining rates for experimental groups (5%NaF applied before immersion in coffee) were: GIC-85.7%, RMGIC-28.6%, and Composite-100%. The GIC group had a significance value of 1.000, RMGIC and Resin Composites of 0.462. The values are tabulated in [Table 4].

This suggested that application of 5%NaF varnish increased the staining potential of coffee, although it was statistically non-significant.

Table 3: Statistics of the first part of the study.

	GIC	RMGIC	RESIN composite	Chi-square value	Significance
Staining absent	5 (71.4)	3 (42.9)	3 (42.9)	1.167	0.592 (N.S)
Staining present	2 (28.6)	4 (57.1)	4 (57.1)		
Total	7 (100)	7 (100)	7 (100)		



Graph 1: Graphical representation of the results of first part of the study.

Table 4: Statistics of the second part of the study.

	Staining		Chi-square value	Significance
	Absent	Present		
GIC				
Control	2 (28.6)	5 (71.4)	0.424	1.000 (N.S)
NAF added	1 (14.3)	6 (85.7)		
RMGIC				
Control	7 (100)	0 (0)	2.333	0.462 (N.S)
NAF added	5 (71.4)	2 (28.6)		
Composites				
Control	2 (28.6)	5 (71.4)	2.333	0.462 (N.S)
NAF added	0 (0)	7 (100)		

DISCUSSION

GIC, RMGIC, and Resin Composite are the most commonly used restorative materials. These are commonly used in the aesthetically pleasing zone. Hence, the color stability of these restorations is of utmost importance from the esthetic point of view.

Fluoride was introduced into dentistry over 70 years ago, and it is now recognized as the main factor responsible for the dramatic decline in caries prevalence that has been observed worldwide.[10] Fluoride present in low, sustained concentrations (sub- ppm range) in the oral fluids during an acidic challenge are able to be absorbed onto the surface of the apatite crystals inhibiting demineralization. When the pH is reestablished, traces of fluoride in solution will make it highly supersaturated with respect to fluorhydroxyapatite, which will speed up the process of remineralization.[11]

The potential to stain the tooth by topical stannous fluoride application[12] has been documented in the literature which is largely due to the improper stabilization of stannous ions (Sn++) in SnF2. Staining potential of APF on various dental restorations has been evaluated by Lin and Huang,[8] and they concluded that GIC was more susceptible to staining with APF when compared to RMGIC and composites.

In the current study, the staining potential of 5% NaF was evaluated. This study showed that all the three types of restoratives which were evaluated, showed significant staining when compared to the respective control groups. GIC showed less potential to be stained when compared to RMGIC and Resin Composites, which were more susceptible to staining from 5% NaF. This might be due to the fact that GIC has higher water content which allows lesser water absorption making it less susceptible to color changes.[13] This finding was in concurrence with study conducted by Lim *et al.* who demonstrated that RMGIC had a higher susceptibility to surface stain than conventional GICs because of their resin content.[14]

Excessive water sorption could reduce the longevity of composites by expanding and plasticizing the resin matrix, hydrolyzing the silane coupling agent, and producing microcracks formations and eventually leading to staining.[15] Some studies have reported high surface roughness of composites even after finishing, due to irregularly arranged inorganic filler particles, which could

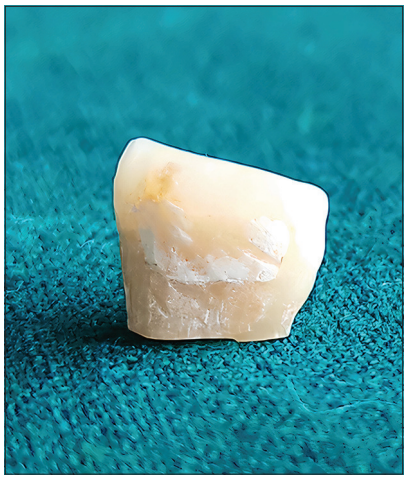


Figure 1: White opaque discoloration over the surface of the resin composite restoration.

result in easier staining over time.[16] These might be the reasons for the higher percentage of staining of RMGIC and composites in the present study.

The discoloration observed in the current study was a white opaque discoloration over the surface of the restoration either as a layer or as discrete strands as shown in [Figure 1].

In the second part of the study, application of 5%NaF varnish increased the staining potential of coffee marginally, although not significant statistically. This is in accordance with the first part of our study, in which we observed that application of 5%NaF resulted in the white opaque discoloration over the surface of the restorations. We hypothesize that this layer might have reduced the stain resistance of the restoratives to coffee.

Since the evaluation methods was visual and did not involve an instrumental one like a colorimeter or a spectrophotometer, this study might have been subjected to bias. Further studies also need to be conducted for evaluation of surface and subsurface alterations of these restorations after application of 5% NaF.

CONCLUSION

5% NaF application resulted in a shade change of all the restoratives tested in the study upto a visually perceptive level. The fluoride application did not significantly influence the staining potential of coffee in the restoratives tested.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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