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Effect of Fluoride Mouth Rinses Inducing Color Change in Esthetic Veneer Restoration – A Spectrophotometric Analysis

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Abstract :

Statement of the problem: Fluoride mouth rinses despite its therapeutic value in controlling the caries progression in the teeth can also induce color change in tooth color restorations with prolonged usage.

Aim: To comparatively evaluate the color change induced by fluoride mouth rinses in esthetic veneer restorations.

Methodology: 60 metal samples (16x16x1.5mm) were distributed into three groups of 20 each to be veneered with experimental esthetic restorative materials. Samples veneered with ceramic (Ivoclar d sign, Ivoclar vivadent, Liechtenstein) constituted Group I. Samples veneered with ceramic repair composite Group –II (Ceram X mono, Dentsply, Germany), indirect composite Group- III (SR Adora, Ivoclar vivadent, Liechtenstein). The samples were stored in 2% fluoride mouth rinse for 12 hours and evaluated for color change using spectrophotometer. The color difference value ΔE was calculated and subjected to statistical analysis.

Results: The mean color difference values ΔE for Group I, Group II, Group III were 15.95 ±1.96, 24.25±2.25, 25.32±1.25 respectively. One way analysis of variance showed a statistically highly significant difference ($p < 0.001$) between the experimental groups at 5% level of significance.

Conclusion : Ceramic veneers were the most resistant to color change induced by the fluoride mouth rinse than Ceramic repair composite and indirect veneer composite and the clinicians need to be aware of this while prescribing fluoride mouth rinses.

Keywords: Fluoride mouth rinse, ceramic, ceramic repair composite, indirect composite, color change.

INTRODUCTION

Rehabilitation of the partially edentulous dentition with fixed partial denture is a predominant modality of treatment over the years. The increased demand in esthetics by the patients have resulted in the diminution of commonly used all metal restorations and led to the development of metal ceramic restorations in which metal substructures are veneered with tooth colored veneering materials. The esthetic outcome of a dental restoration predominantly depends on the color and optical properties of the veneering material employed (1).

The commonly used teeth colored veneering materials are acrylic resin, ceramics and composite resin based materials (2). The advantages of acrylic resin include ease of fabrication, ability to retain the glossy surface and good initial esthetics. However, they had their own disadvantages like polymerization shrinkage, large thermal dimensional change, high wear rate and eventual discoloration (3).

Ceramics when used as a veneering material or as high strength ceramic frameworks, have demonstrated their high esthetic qualities of the restoration which resulted in lesser plaque accumulation (4). However, they have some drawbacks such as lengthy complicated procedures of fabrication, brittleness and general abrasiveness for the opposing dentition (4). Some of these characteristics have led to the use of an alternative veneering material like composite resin.

Resin composites addressed some of the shortcomings of the ceramics like less abrasiveness, less brittleness and easy fabrication procedures along with acceptable esthetics (4). Dental restorative composite materials can be either direct or indirect resin composites. Direct composite materials involve use of traditional composite applied directly on the prepared tooth.

These materials were originally intended for use in anterior restoration where esthetics is the main concern and currently used in posterior region also (5). One major problem that still exists with direct technique is the effect of polymerization shrinkage which results in improper sealing of tooth- restorative material interface, leading to sensitivity problems, recurrent caries and discoloration (3).

Indirect resin composites or laboratory cured composites were introduced mainly to overcome the limitations of traditional direct composites. The potential advantage of these materials is that a slightly higher degree of polymerization is obtained which improves the physical properties and resistance to wear (3). Indirect composite resin materials are being widely used as a viable alternative to porcelain as a veneering material for the metal supported restorations (6). However, long term clinical studies are required to ascertain the longevity of these materials in the oral environment.

In the anterior visible zone, fractured ceramo-metal restoration is considered as an esthetic emergency and requires immediate attention as it leads to an esthetic and

functional compromise. The use of ceramic repair composite material becomes important at this juncture as porcelain processing which requires high temperature firing where new porcelain cannot be added to the existing restoration intra-orally. Various types of materials like acrylic resins have been used as ceramic repair composite material. Composite resin has become the material of choice for ceramic repair procedure due to their improved mechanical properties, better shade matching and ease of manipulation (3). The clinical success of the ceramic repair is almost entirely dependent on the integrity of the bond between ceramic- metal substrate and composite resin (8).

Ever since the introduction of nanotechnology to dentistry, nanocomposites have been developed with the advantages of reduced polymerization shrinkage, increased mechanical properties, improved optical characteristics and better gloss retention (7). Wear resistance of nanocomposites has been shown to be comparable or superior to that of conventional composite resins (7). The use of nanocomposites as a ceramic repair material has been reported in the literature.

Staining or discoloration may compromise the required esthetic results of veneering materials and thereby interfere with the longevity of the restoration. These esthetic veneering materials especially composite resin may undergo a transition in color when exposed to various staining agents such as tea, coffee, soda, mouth rinses, nicotine smoke etc. (7). Porcelain is resistant to discoloration and optical properties closely simulate that of the natural teeth (9). In-vitro studies have shown that some topically applied fluoride agents cause surface changes of dental materials including porcelain, GIC, and composite restorations (10). Resistance to staining of esthetic materials to a major extent will depend on the patient's oral hygiene maintenance (11). The use of mouth rinse is an adjunct in controlling the development and progression of periodontal disease and dental caries (5). They are also prescribed and used largely in the maintenance of fixed dental restorations. Commercially available mouth rinses are either alcohol based, fluoride based, or chlorhexidine gluconate based mouth rinses (7).

Fluoride incorporated in mouth rinses have an anti-carious effect, prevent demineralization and enhance remineralization of carious and non-cavitated enamel (12). However frequent use of fluoride mouth rinses may produce deleterious effects on the optical properties and surface characteristics of esthetic veneering materials such as glass containing ceramics and composite resins. Fluoride mouth rinses are capable of producing perceptible color change of veneering materials because fluoride has the ability to etch silica which is a major component of veneering materials (13, 14).

There are very limited studies on the effects of fluoride mouth rinses on the color stability of esthetic restorative veneering materials. In view of the above, the present study was conducted to address this concern. The aim of the study was to comparatively evaluate the color stability of ceramic veneering material, ceramic repair composite material and indirect composite veneering material after immersion in fluoride mouth rinse.

Methodology

A total of 60 samples of metal substructures were finished and polished. The metal substructures (16X16X1.5mm) were divided into 3 groups as GROUP-I, GROUP-II, & GROUP-III, consisting of 20 samples each and were veneered with ceramic veneering material, ceramic repair composite material and indirect composite resin material respectively. All the 60 samples were distributed into three groups and veneered with experimental esthetic veneering materials and immersed into artificial saliva 24 hours and immersed in fluoride mouth rinse for 12 hours and tested for color change using a spectrophotometer.

GROUP-I: Comprised of 20 test samples, Fluorapatite leucite ceramic (Ivoclar d sign, Ivoclar vivadent AG, Liechtenstein), A3 shade was veneered over metal substructure.

GROUP-II: Comprised of 20 test samples, Ceramic repair composite (Angelus, Brazil, Ceram X mono - Nano Ceramic Composite, Dentsply, Germany) A3 shade was veneered over metal substructure.

GROUP-III: Comprised of 20 test samples, Indirect veneering composite resin material (SR Adora, Ivoclar vivadent AG, Liechtenstein) A3 shade was veneered over metal substructure.

Veneering of the metal substructure with ceramic (GROUP-I):

In this study, Fluorapatite leucite ceramic (Ivoclar- d sign, Ivoclar Vivadent AG, Liechtenstein, and GERMANY) was employed for veneering the 20 samples of the metal substructure. A3 shade was used for veneering all the samples. Veneering of the ceramic was done in such a way that all the samples had a uniform thickness of 1.5 mm. All the test samples were fired in dental ceramic furnace – Vita Vacumat 100 (Vita, Bad Sackingen, and GERMANY).

Veneering of the metal substructure with Ceramic repair composite (GROUP-II):

In this study, ceramic repair composite (Ceram X mono, Nano-ceramic composite, Dentsply, Germany) was employed for veneering the 20 samples of metal substructures which were sand-blasted and steam-cleaned, acid etched with 9.5% hydrofluoric acid and veneered with composite and light cured for addition of ceramic repair composite.

Veneering with indirect composite resin: (GROUP-III)

The indirect composite resin material (SR Adoro, Ivoclar Vivadent AG, Liechtenstein, and GERMANY, VITA LUMIN (A3 shade) was employed and light cured according to manufacturers instructions.

All the 60 samples of the metal alloy substructure with the three veneering materials were immersed in artificial saliva for 24 hrs. to mimic oral environment were considered as control group (GROUP-I, GROUP-II, GROUP-III). The 60 samples of the three veneering materials were immersed in fluoride mouth rinses and subjected to fiber optic spectrophotometric evaluation to obtain basic color parameters (L*, a*, b*). The color of the ceramic veneering test samples in this study was analyzed by using the Fiber Optic Spectrophotometer (USB 2000, ocean optics, UK). An oo II rad C software was used to analyze

the data. CIE illuminant D65 was used in all color measurements. CIELAB (1976) color space was used for the color measurements.

CIE Lab* is expressed by the L* coordinate representing color luminosity, varying from white to black, and the a* and b* coordinates representing the chromaticity of the colour, with axes varying from green to red and blue to yellow, respectively. The means of the values obtained were calculated, and the L*, a*, and b* parameters were determined. The colour changes (ΔE^*) after 30 days were calculated from the changes in CIE L*, a*, and b* values (ΔL^*, Δa^*,Δb^*) as follows:

$$\Delta E_{ab}^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

All the parameters of color distribution were measured and analyzed by the fiber optic spectrophotometer (USB 2000, ocean optics, UK) and the measurements for color differences ΔE thus obtained for the twenty test samples of the each veneering systems were tabulated and statistically analyzed.

RESULTS

Table 1 shows the mean color difference ΔE for the experimental groups 15.95±1.96 for ceramic veneering materials (Group-I), 24.25±2.25 for ceramic repair composite material (Group – II), 25.32±1.25 for indirect composite veneering material (Group- III).

Table 2 shows the results for ANOVA conducted to test the difference between the means for the three experimental groups at 5% significance. Results shows there is a statistically highly

significant difference between the three experimental groups with respect to means of color difference with an F value =74.11 & p value ≤ 0.001 at 5% level of significance (α = 0.05).

Table 3 shows the results for the Post Hoc analysis. Since the ANOVA showed statistically significant difference between the three experimental groups. Post hoc Analysis using Tukey-HSD test was done to compare the difference between means among the three experimental groups. There was a statistically significant difference between Group I, ceramic veneering material and Group – II, ceramic repair composite material and Group I, ceramic veneering material and Group – III, indirect composite veneering material p≤0.001. However, there was no statistically significant difference between Group– II ceramic repair composite material and Group – III indirect composite veneering material p≥0.05, p = 0.486.

TABLE – 1: Descriptive statistics for the color difference value ΔE

S.No	Groups	N	Mean	Std. Deviation
1.	Ceramic veneers	20	15.9540	1.91665
2.	Ceramic repair material	20	24.2590	2.19186
3.	In direct composite veneers	20	25.2320	1.22183
	Total	60	21.8150	4.56488

TABLE – 2: ANOVA comparing the mean ΔE values between the Groups

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1040.007	2	520.003	156.460	.000
Within Groups	189.443	57	3.324		
Total	1229.450	59			

TABLE – 3; Post hoc Tukey HSD pair wise comparison between the Groups

Multiple Comparisons

Dependent Variable: values

Tukey HSD

(I) groups	(J) groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-8.30500*	.57650	.000	-9.6923	-6.9177
	3.00	-9.27800*	.57650	.000	-10.6653	-7.8907
2.00	1.00	8.30500*	.57650	.000	6.9177	9.6923
	3.00	-.97300	.57650	.219	-2.3603	.4143
3.00	1.00	9.27800*	.57650	.000	7.8907	10.6653
	2.00	.97300	.57650	.219	-.4143	2.3603

*. The mean difference is significant at the 0.05 level.

DISCUSSION

The success of a fixed partial denture is dependent on biological factors, mechanical factors and esthetic factors. Esthetic factors play a dominant role mainly when rehabilitating anterior esthetic zone. Dental porcelains have established themselves as an ultimate esthetic veneering material because of their ability to mimic the natural tooth appearance, good wear resistance and color stability (15).

In spite of obtaining a stable color match by proper selection of esthetic veneering materials and improved processing techniques it has been found that optical properties and surface topography continues to change during the course of time. Several authors have attributed the change due to interaction of various chemical agents that come in contact with the veneering materials. These agents may be used either by dentists for the therapeutics purpose or these agents may be in the form of food substances consumed by the patients.

The use of mouth rinses is highly recommended to patients in order to control caries and periodontal diseases. In addition expanded use of mouth rinses are widely prescribed for the implant maintenance (5). Fluoride are also been shown to alter the bacterial metabolism which could alter the progression of periodontal diseases.

By composition, dental ceramics contains large volume of glass component that can be easily etched and pitted by the presence of fluoride ions (16). Repeated applications of fluoride can alter the surface texture of dental ceramics. The acidity of the fluoride can causes etching of silica is a major component of dental ceramics (16). Composite resins are susceptible to discoloration that may be intrinsic or extrinsic. Intrinsic factors involve the alteration of resins

matrix itself or the interface of matrix and fillers or hydrolysis in resin matrix itself. Resin matrix is a major component of composite materials has been reported to play critical role in color stability and affected by different pH of solution and alcohol concentration.[18] Mouth rinses has been reported to produce surface discoloration of esthetic veneering materials mainly composite resin based materials. According to the study by Weiner and Peungoda, ethanol in the concentration of 21.6% was considered to produce softening effect on composite resin (17). Also irreversible processes such as leaching of material components have been shown to occur in the presence of fluoride and ethanol. Extrinsic factors of discoloration include staining by food and beverages tooth brushing and absorption /adsorption of colorings agents as a result of contamination from various exogenous sources (15).

Many studies have reported the effect of various agents on the optical properties and surface qualities of traditional composite resin and feldspathic porcelain (15).

Results of color change using spectrophotometer evaluation in the present study shows the mean total color change ΔE of Group(I) 15.95 of ceramic veneering samples after immersion in fluoride mouth rinse was much lesser than the color change observed with ceramic repair composite 24.25 and indirect veneering composite 25.32.

This study used Ceram X (nano composite) as the veneering material for ceramic repair. A nanoceramic resin composite, comprises organically modified ceramic nano particles and glass fillers and a resin matrix that is replaced by a matrix full of highly dispersed methacrylate modified poly siloxane particles (7). The staining susceptibility may be attributed to these structural differences. In a previous study, conducted by Celik. C et al, on the color stability of CeramX (Nanoceramic Composite) using alcohol free mouth rinses, exhibited mean color change ΔE 3.52 lesser than color change observed for Nanoceramic Composite resin used in the study after immersion in fluoride mouth rinse (7).

Previous studies have shown the presence of hydroxyl group in the resin matrix, renders the indirect composite resin more susceptible to water absorption and solubility. In contrast sr adoro consists of new aromatic, aliphatic UDMA with the absence of hydroxyl group; thereby the materials become less susceptible to water absorption (1). An early study done on color stability of five esthetic materials when immersed in a coffee solution displayed lower discoloration for Targis (indirect composite resin material). This could be attributed to the method of polymerization where light and heat source were used and this helps in the higher degree of conversion of residual monomer which influences the staining potential of the material to some extent (18). Similar method of polymerization was employed with Indirect Composite resin (SR Adoro) in this present study.

One way analysis of variance ANOVA at 5% level of significance observed a statistically significant difference between the three experimental groups with respect to changes in color stability. A statistically no significant color difference was observed when comparing the ceramic repair composite (GROUP-II) and indirect composite resin (GROUP-III) materials in non-fluoride mouth rinse is P-value of 0.219 respectively. However the color variation observed among the veneering materials (GROUP-I, GROUP-II, GROUP-III) when immersed in fluoride mouth rinse was statistically significant.

Ceramic veneering material showed least mean color changes. The other variables which could have influenced the color differences are PH of the test agents, immersion period and coloring agents used in the mouth wash (16, 12). The indirect veneering composites used in this study (SR Adoro) contain silicon dioxide as main filler and this component is found to undergo etching when treated with fluoride mouth rinse.

Most of the studies conducted previously on color stability using CIELab system considered ΔE = 33 as the upper limit of color change which is clinically acceptable. The results obtained in this study for evaluating color stability yielded ΔE = 15.95,24.25,25.32 for ceramic veneering material immersed in fluoride mouth rinse and indicating the color change is insignificant when tested with fluoride the mouth rinses. The ceramic repair composites and indirect composite resin samples exhibited a difference in color change with ΔE values more than ceramic veneering material,however within the accepted clinical esthetic perception range.

The inference of the results emphasize that it is difficult to entirely correlate laboratory finding with clinical behavior of any restorations since several factors like ph of saliva, the type, duration and frequency of food and beverage intake by the patient, oral hygiene status and tooth brushing habits play a role in the oral environment which could influence color change cannot be fully simulate laboratory conditions. Therefore to draw a more authentic correlation between the clinical studies and lab measurements, further in vivo clinical evaluation is suggested.

CONCLUSION

Within the limitations of the study, it can be concluded that ceramic veneering materials exhibited the least perceptible color change than the ceramic repair composite and indirect composite veneer materials following immersion in fluoride mouth rinses and hence prudent attention should be exercised by the clinicians while prescribing fluoride mouth rinses in patients with esthetic restorations.