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An evaluation of color stability of contemporary esthetic restorative materials exposed to different children health drinks – an in vitro study.

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Abstract:

Background: Children consume foods that are colorful and contain food additives that stain not only the tooth structure but also the restorations. As esthetics is of prime concern for both parents and children nowadays, long term color stability of restorative materials is of utmost importance.

Aim: To evaluate the color stability of contemporary esthetic restorative material (conventional GIC and resin modified GIC) when exposed to different children's beverages (Frooti, Amul cool, Bournvita and Artificial Saliva).

Method: A total of forty specimens (10 X 2mm) were made with each restorative material i.e. Ketac Molar (CGIC) and GC FUJI II LC (RMGIC). These specimens were again divided into 4 subgroups (n=10) for immersion in Frooti, Amul cool, Bournvita and artificial saliva (control group). The color change (ΔE values) was measured before and after immersion into the beverages using spectrophotometer.

Results: Both tested material showed color change; however RMGIC showed greater ΔE values compared to CGIC in all staining solution used. Amul cool had the maximum staining potential followed by Bournvita, Frooti and Artificial saliva.

Interpretation and conclusion: Among the two materials, CGIC (Ketac Molar) showed less color change as compared to RMGIC (GC FUJI II LC) indicating better color stability.

Keyword: Color stability, Resin modified GIC, Conventional GIC, Beverages; Spectrophotometer.

Introduction

To achieve esthetics, four basic determinants are required in sequence; viz., position, contour, texture and color[1]. A major challenge of esthetic dentistry is to achieve a perfect color match between the tooth and the restoration.

As color is one of the most desirable properties of an esthetic restorative material, maintenance of the matched color for the entire length of its service life may determine the success or failure of the material. Thus, it is desirable that the restorative material be resistant to changes in its intrinsic color.[2]

In pediatric dentistry glass ionomer cements have been recommended as restorative material for variety of preventive and restorative procedures, tunnel restoration and cementation of orthodontic bands. The conventional glass ionomer cement (GIC) is a fluoride-containing restorative material with non-satisfactory esthetics. Thus, different hybrid restorative materials such as high-viscosity GIC, polyacid-modified resin composite, giomers, and resin-modified glass ionomer cement (RMGIC) have been developed to improve some physical properties of the materials, including the esthetics.[3]

Increased urbanization has led the society to revolve away from household cooking to processed food and beverages which include a wide range of coloring agents that not only increases the risk of obesity, diabetes, and cardiovascular diseases but also affect the color stability of the esthetic restorative materials

Thus, for suitable performance, longevity and good clinical success esthetic material should exhibit adequate color stability. So the aim of the study was to evaluate the color stability of these tooth colored restorative materials when immersed in different children health drinks.

Material and Method

The present in vitro study was carried out in Department of Pedodontics and preventive dentistry, Darshan Dental College and hospital Udaipur in collaboration with Department of Horticulture, Rajasthan College of Agriculture Udaipur.

Figure:1 Armamentarium used in the study.

A total of eighty disk shaped specimen were fabricated using two group of contemporary esthetic restorative material i.e. conventional GIC (Ketac Molar 3M ESPE) and Resin modified GIC (GC FUJI II LC). For preparation of test samples a Teflon mould sheet with aperture of diameter 10mm and depth 2mm were used. Forty standardized specimens were prepared for each group of restorative material by mixing powder and liquid according to manufacturer's instruction at room temperature (23^0c, fold on technique).

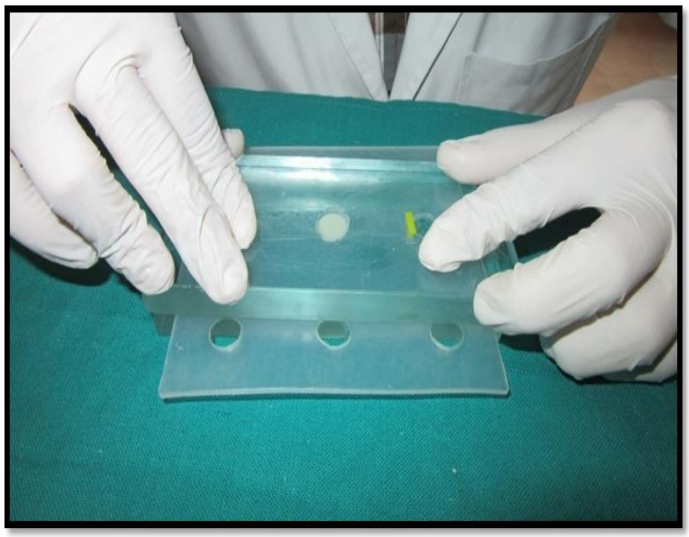

Figure:2 Conventional GIC (Ketac Molar) packed into Teflon mould & covered with mylar strip and two glass slab to set under constant hand pressure.

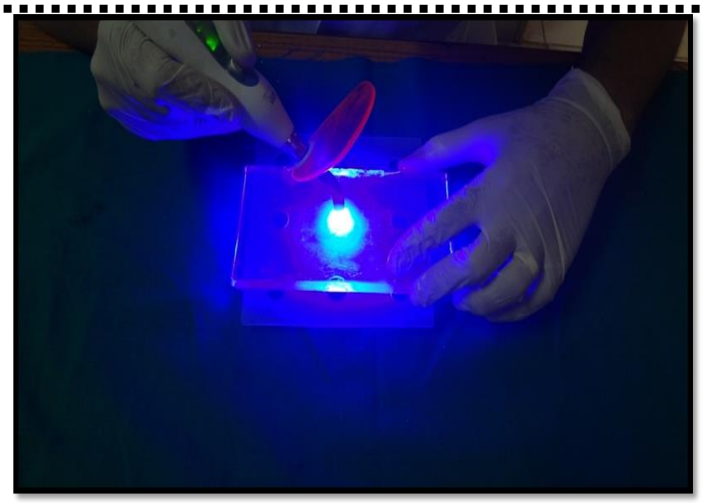

Figure 3: RMGIC (GC FUJI II LC) being light cured using LED light.

The material was packed into the mould with cement carrying instrument, covered by two mylar strips to obtain a smooth surface and were allowed to set by holding two glass slab on either side of Teflon mould with constant hand pressure. Chemically activated GIC (conventional GIC) were allowed to set completely and RMGIC was light cured according to recommended exposure time of 20s with an LED light of output 600nw/cm^2. The prepared samples were marked on one side for better identification.

Figure 4: Immersion media used in the study.

After preparation, the specimen was kept in distilled water for 24 hours to achieve rehydration. After rehydration samples were rinsed and dried with tissue paper and baseline color measurement were made. After baseline evaluation the 40 specimens of each group were subdivided further into 4 subgroups of 10 specimens each according to different children's beverages. The children beverages used for the study were as follows:

Subgroup I - A mixture of Frooti and artificial saliva (600 ml)

Subgroup II - A mixture of Flavoured milk (Amul Cool) and artificial saliva (600 ml)

Subgroup III - A mixture of Bournvita milk and artificial saliva (600 ml)

Subgroup IV – Control group (artificial saliva) (600 ml)

Figure 5: Rehydration of samples by placing them in distilled water for 24 hours.

All staining solutions were commercially available except for bournvita which were prepared by mixing 125 ml of milk with (10g) sugar and (20g) bournvita. Specimens were immersed in their respective solution at 37^{0}c for 24 hours and in each solution artificial saliva (Wet mouth, ICPA Health products, Ankleshwar) was used in order to stimulate oral condition. Temperature was controlled using a thermostatically controlled incubator. Color measurement were made after day 2 (T2), day 7 (T7) and day 15 (T15).

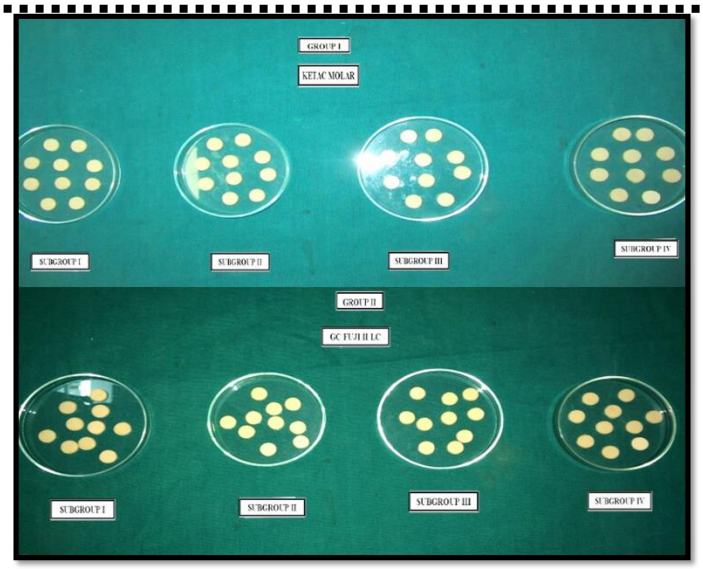

Figure 6: Distribution of samples into 4 subgroups according to immersion media used.

The specimens were rinsed with distilled water for 5 min and bottled dried with tissue paper and before color measurement. Color difference of each specimen was measured by reflectance spectrophotometer (color flex, hunter lab).L* a* b* value of each specimen after immersion at each specified time interval (T2, T7, T15). Before each measurement spectrophotometer were calibrated according to manufacture recommendation. The calibration was done against white and black standard background with known color dimension.

Figure 7: Specimens kept inside incubator at 37^0c temperature.

Values were recorded in commission International del'eclairage (CIE) CIEL*a*b* color system. The CIELAB system is an approximately uniform color space with co-ordinates for lightness, namely white/black (L), red/green (a) and yellow/blue (b). L* a* b* values for each specimen were measured 3 times by placing each specimen on measuring head. The values of ΔL^*, Δa^*, Δb^* after 3 measurements were automatically calculated by spectrophotometer and recorded. Thus, ΔE is more meaningful than individual ΔL^*, Δa^*, Δb^* values. Resistance to staining effect is expressed in ΔE^* unit and calculated from the mean ΔL^*, Δa^*, Δb^* values for each formula with following formula: $\Delta E = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{½}$.

Where ΔL^*, Δa^*, Δb^* are the differences in L*, a* and b* values before (T0) and after immersion at each time interval T2, T7, T15).

Figure 8: Color difference ΔE calculated using spectrophotometer.

Results

Mean, standard deviation and test of significance and test of significance of mean color change between group-I (Ketac Molar) and group-II (GC FUJI II LC) were calculated using one way ANOVA and multiple range tests by Tukey-HSD are shown in (Table I & II) respectively.

In **group I** (Ketac Molar) and **group II (**GC FUJI II LC) highest amount of color change (ΔE) were seen in specimen immersed in Amul cool, followed by Bournvita, Frooti and artificial Saliva at day 2, day 7 and

day 15 which were statistically significant ($p \leq 0.05$) when compared with samples of other immersion media. When intergroup comparison of Mean ΔE of samples of different subgroups at day 2, day 7 and day 15 (Table 3,4,5) were made GC Fuji II LC showed significantly higher amount of mean color change (ΔE) in all of its immersion media except for the artificial saliva as compared with mean ΔE of Ketac molar.

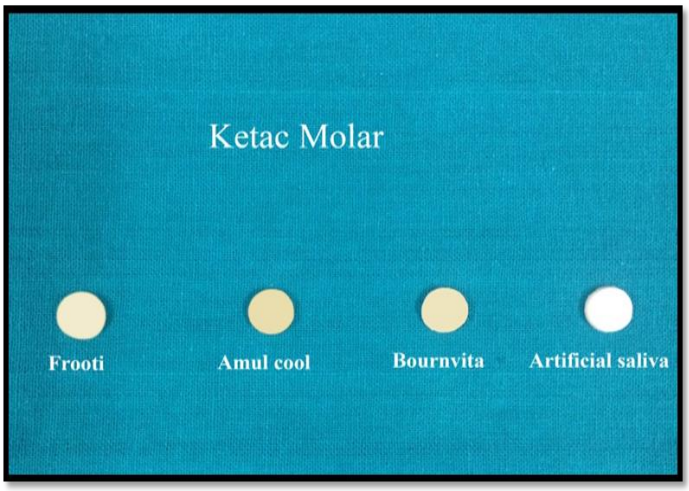

Figure 9: Showing color difference seen at the end of day-15 in specimen of Ketac Molar.

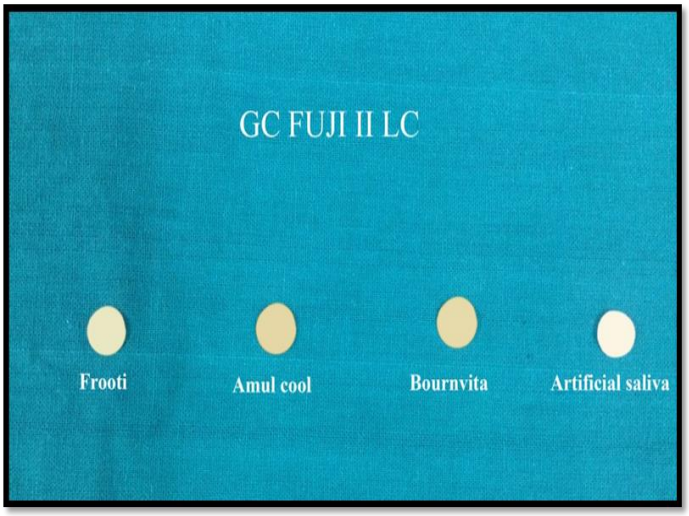

Figure 10: Showing color difference seen at the end of day-15 in specimen of GC FUJI II LC.

Statical analysis

Measurements were tabulated and statistically analysed using SPSS version 15.0 statistical analysis software.

Table 1: Color change between different subgroups for group I (KETAC MOLAR).

Time	Sub-group	Mean ± SD	p-value	Significant # group at 5% level
Day-2	Frooti Amul cool Bournvita Artificial saliva	1.87±0.42 3.23±0.92 2.54±0.54 1.32±0.34	<0.001	II V/S I, III, IV III V/S IV
Day-7	Frooti Amul cool Bournvita Artificial saliva	2.57±0.58 4.29±0.76 3.10±0.28 1.54±0.57	<0.001	II V/S I, III, IV I V/S IV III V/S IV
Day-15	Frooti Amul cool Bournvita Artificial saliva	3.43±0.44 5.75±0.58 4.14±0.40 1.56±0.53	<0.001	II V/S I, III, IV I V/S III, IV III V/S IV

Table 2: Color change between different subgroups for group II (GC FUJI II LC).

Time	Sub-group	Mean ± SD	p-value	Significant # group at 5% level
Day-2	Frooti Amul cool Bournvita Artificial saliva	2.17±0.61 3.83±0.71 3.00±0.75 1.17±0.32	<0.001	II V/S I, III, IV I V/S III, IV III V/S IV
Day-7	Frooti Amul cool Bournvita Artificial saliva	3.16±0.33 5.12±0.69 4.06±0.61 1.11±0.45	<0.001	II V/S I, III, IV I V/S III, IV III V/S IV
Day-15	Frooti Amul cool Bournvita Artificial saliva	4.16±0.40 6.42±0.75 5.32±0.62 1.07±0.43	<0.001	II V/S I, III, IV I V/S III, IV III V/S IV

Table 3: Intergroup comparison of mean ΔE of samples of different subgroups at day-2.

GROUP I (ketac molar	Frooti	Amul cool	Bournvita	Artificial saliva
Mean	1.87	3.23	2.54	1.32
SD	0.42	0.92	0.54	0.34
GROUP II (GC	Frooti	Amul cool	Bournvita	Artificial saliva

FUJI II LC)				
Mean	2.17	3.83	3.00	1.17
SD	0.61	0.71	0.75	0.32
t-value	1.28	1.63	3.05	-1.00
P value	0.22	0.12	0.13	0.33

Table 4: Intergroup comparison of mean ΔE of samples of different subgroups at day-7.

GROUP I (ketac molar	Frooti	Amul cool	Bournvita	Artificial saliva
Mean	2.57	4.29	3.10	1.54
SD	0.58	0.76	0.28	0.57
GROUP II (GC FUJI II LC)	Frooti	Amul cool	Bournvita	Artificial saliva
Mean	3.16	5.12	4.06	1.11
SD	0.33	0.69	0.61	0.45
t-value	2.78	2.56	4.51	-1.86
P value	0.01*	0.02*	<0.001**	0.08

Table 5: Intergroup comparison of mean ΔE of samples of different subgroups at day-15.

GROUP I (ketac molar	Frooti	Amul cool	Bournvita	Artificial saliva
Mean	3.43	5.75	4.14	1.56
SD	0.44	0.58	0.40	0.53
GROUP II (GC FUJI II LC)	Frooti	Amul cool	Bournvita	Artificial saliva
Mean	4.16	6.42	5.32	1.10
SD	0.40	0.75	0.62	0.43
t-value	3.87	2.25	5.05	-2.10
P value	<0.001**	0.04*	<0.001**	0.06

P value: *Significant **Highly significant

Discussion

In pediatric dentistry, long term color stability of restorative materials is important not only because of esthetics and the additional costs associated with replacement of restorations, but because of the multiple visits needed for replacement might lead to behavior management problems and increase dental anxiety in children.[4]

Consumption of soft drinks is known to have increased in recent years, and is especially high among younger individuals. Other drinks frequently consumed by children include fruit juices and milk, which may include aromatic substances such as chocolate, banana and strawberry and other flavorings added to encourage consumption among children.[5]

GIC first introduced by Wilson and Kent in 1972 is considered to be the best restorative material in children because of its property of low coefficient of thermal expansion, physicochemical bonding to both enamel and dentin, good biocompatibility and good marginal integrity.[6]

Many studies have evaluated the effect of cola on color stability of these tooth-colored restorative materials;[7,8] however the effect of chocolate milk and fruit beverages has not been reported. Therefore aim of our study was to measure the color stability of GIC and resin modified GIC after exposure to various children beverages (Bournvita, Amul cool, Frooti and Artificial Saliva)

Discoloration can be evaluated visually and by instrumental techniques (spectrophotometer and colorimeter).[9] Color evaluation by visual comparison has been shown to be unreliable as a result of inconsistencies in color perception specification among observers. Since instrumental measurement eliminates the subjective interpretation of visual color comparison.[9,10]

Colorimeters and spectrophotometers have been most commonly used to measure color change in dental materials. Spectrophotometer have been shown to be more accurate in measuring color change than colorimeters as spectrophotometers contains monochromators and photodiodes that measure the

reflectance curve of a product's color every 10nm or less.[9,10]

Various studies have reported different threshold of color difference values above which the color change is perceptible to the human eye. These values ranged from ΔE equal to 1, between 2 and 3, greater than or equal to 3.3 and greater than or equal to 3.7. Values of ΔE between 0 and 2 were imperceptible, values of ΔE in the range of 2 to 3 were just perceptible, values from 3 to 8 were moderately perceptible and the values above 8 were markedly perceptible. A ΔE value of 3.7 or less is considered to be clinically acceptable.[10]

The present study showed that conventional GIC (Ketac molar 3M ESPE) to be more color stable than resin modified GIC (GC FUJI II LC). The results are in agreement with previous studies done by Tunc ES *et al*,[5] Bagheri R *et al*,[11] Imparato JC *et al*,[12] Lim BS *et al*, [13] Prabhakar AR *et al* [14] and Vance M *et al*.[15]

The conventional Glass ionomer cements (CGIC) and the ones modified by resin (RMGIC), posses' different composition so their susceptibility to surface pigmentation will be different. Difference in color stability among restorative materials can be ascribed in part to the size of colorant particles and the constituents of restorative material (water and monomer).[5]

In a study done by Khokhar ZA *et al*[16] showed that fine colorant particles may be deposited into the pits of light polymerized restorative material.

Discoloration may be related to both surface adsorption and absorption of colorants. Cattani-lorente MA *et al*,[17] Small IC *et al*,[18] in their study on effect of water sorption on physical properties of various Glass ionomer cements concluded that water absorption by RMGIC is higher than that absorbed by conventional GIC due to absorption of water by HEMA particles a significant resinous component in the constitution of RMGIC.

According to Knobloch *et al*,[19] resin modified glass ionomer cement showed higher water sorption due to their hydrophilic nature. Iazzetti G *et al* [4] also suggested that materials containing hydrophobic monomers, such as composite resin, are more stain-resistant than materials containing hydrophilic monomers, such as RMGICs.

Another reason that explains this difference in discoloration may reside in the fact that conventional GIC has greater amount of water in its composition as compared to RMGIC, therefore it will absorb less water and consequently less pigments Bagheri R *et al.*[11]

According to Iazzetti G *et al*,[4] Kalampalikis E *et al*,[20] Lopes LM *et al*[21] Autio-gold JT *et al*[22] and Debner T *et al*[23] Resin modified GIC were found to be more color stable than conventional GIC. This is in contradiction to the results found in our study. This may be due to an increased in surface roughness of conventional GIC than resin modified GIC as thereby retaining a larger number of pigments Lopes LM *et al*.[21]

According to Chhabra C *et al* [3] the relative susceptibility of GIC for staining could be attributed to the porosity of glass particles, dehydration after setting and drying, and microcracks that allows staining and discoloration of restoration.

Another reason for lack of color stability in conventional GIC could be due to the polyacid content in the material which can be explained by degradation of metal polyacrylate salt as stated by Kalampalikis E *et al.* [20]

According to Bagheri R *et al*[11] the staining of drinks and solution vary according to their composition and other characteristic. In present study for all the restorative material tested, the greatest change in color were observed after immersion in Amul cool (chocolate flavoured milk), followed by Bournvita (chocolate milk), Frooti and Artificial Saliva.

Color change in Amul cool and Bournvita could be ascribed to the presence of cocoa solid which was substantiated by findings of Sangeeta KM *et al* [24] and Hotwani K *et al*.[25]

While color change in Frooti could be due to food colorant absorption as stated by Azer SS et al.[26] In our study artificial saliva was used as control group. Samples in control group did not show any color change which could be due to absence of coloring agent in water as confirmed by Prabhakar AR *et al*.[14]

Prabhakar AR *et al* [14] stated that artificial saliva and other storage media such as lactic acid, deionized water and water did not show any significant color change. In contrast Uzun G *et al* [27] stated that water also promoted slight color change.

In present study, it was also observed that discoloration of samples increased with time for both groups of restorative material used in all of the immersion media except for artificial saliva over a period of 15 days.

These results are consistent with study done by Bansal K *et al* [28] and Malekipour MR *et al* .[29] However Bezgin T *et al* [30] found that good oral hygiene, i.e., brushing at regular intervals, decreases the amount of color change in esthetic restorative materials over time.

Since it is an in vitro study role of saliva or oral clearance in retarding the long-term build-up of stains in oral environment cannot be stimulated. Attention regarding certain other contributing factors such as proper Powder/liquid ratio, polymerization, surface protection, finishing and polishing should be focused which will in turn help in long-term color stability of tooth colored restorative materials.

Incentive behind this study will help the professionals to advise patients about the staining characteristics of various beverages on tooth-colored restorations. However, we recommend further studies considering surface irregularities, water sorption, and dissolution of theses restorative material using temperature and pH as variables.

Conclusion

Within the limitation of study following conclusions were drawn

1. The degree of colour change in the restorative materials tested varied according to the children beverages to which they were exposed.
2. Resin modified GIC (GC FUJI II LC) showed maximum colour change in all staining solutions as compared to conventional GIC (Ketac molar).
3. Among staining solutions Amul cool showed maximum colour change followed by Bourn Vita, Frooti and Artificial saliva.
4. Elevated ΔE was noticed with increased in immersion period.

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