






Effect of Thermocycling on the Colour Stability of Aesthetic Restorative Materials: An in-vitro Spectrophotometric Analysis

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Abstract

Objective: To compare the color stability of Cention N, Fuji IX GP Extra, and Fuji IX GP after thermocycling. **Material and Methods:** Ten discs of each material of dimension 10 x 1 mm were prepared using a split mold. The preparations of the specimens were done according to the powder/liquid ratio as recommended by the manufacturers [4.6:1, 3.4:1 and 3.6:1 for the groups I, II, and III, respectively]. After setting, the samples were retrieved, and the thickness of each specimen was measured using a micrometer at five different locations. The specimens with variations in thickness, porosity or cracks were discarded and thus not included in the study. The selected specimens were stored in distilled water for 24 hours prior to testing. The prepared specimens were thermocycled at 5°C and 55°C, with a dwell time of 15 seconds for 250 or 500 cycles. Subsequently, the color parameters of the discs were measured using a spectrophotometer. The data were analyzed using two way ANOVA test, and a p-value <0.001 was considered. **Results:** Thermocycling resulted in changes in the color of both Glass Ionomer cement and Cention N (p<0.001). Among the materials tested, Cention N showed superior color stability. **Conclusion:** Cention N exhibited better color stability compared to Glass ionomer cements.

Keywords: Dental Materials; Glass Ionomer Cements; Esthetics, Dental.

Introduction

The demand for dental esthetic procedures has tremendously increased in the recent past. In order to cater for such needs a variety of materials have been developed [1]. Glass ionomer cement (GIC) was the first aesthetic restorative material, with an ability to release fluoride and bond to the tooth chemically, has been the material of choice for a very long period of time [2]. However, its low strength, abrasion resistance, moisture sensitivity necessitated newer and improved materials. Resin composites, a combination of a resinous matrix with inert dispersed filler particles coupled with a silane agent, have been introduced as an alternative choice of materials [3]. Research and innovation in these materials, processing methods, and manipulation techniques have led to the development of a variety of dental composites to cater to the needs of a wide range of clinical conditions. Yet, composites are known to have no anticariogenicity and cause post-operative sensitivity. To overcome these drawbacks, attempts have been made to combine the composites with GIC [2,3].

Alkasite, a new category of filling material, essentially a subgroup of the composite material class, was introduced considering the September 2014 FDI Policy of phasing down amalgam usage. Cention N is an alkasite, which is a resin-based self-curing (with optional light-curing) powder liquid restorative material that is cost-effective, shows better handling property than composites, has fluoride-releasing properties and has a strength that is comparable to amalgam [4]. Compared to GIC, Cention N has better aesthetics, as has been stated by the manufacturers.

The aesthetics of restorations is cumulative of colour, translucency and opacity, light reflectance and transmittance, and surface texture [1]. The colour of dental restorative materials is measured using devices such as shade guides, colorimeter, and spectrophotometers. These use colour spaces for reproducible representations of the colour [5]. The ADA recommends the use of CIELAB (Standard Commission Internationale de L, Eclairge) colour system, which expresses color in terms of luminosity and chromaticity [6].

Glass ionomer cement is widely used in Class III as well as Class V preparations in the anterior teeth due to its favorable esthetic and biological characteristics along with ease of handling [7]. Recently, a new Glass ionomer restorative material, GIC Fuji IX GP Extra (GC Corporation, Tokyo, Japan), that utilizes SmartGlass™ technology imparting better esthetic qualities compared to original GIC Fuji IX GP (GC Corporation, Tokyo, Japan) was introduced in multiple shades.

Colour stability directly corresponds to the clinical success of aesthetic restorative materials. Both composites and GICs have shown varying clinical degradation, even in the absence of mechanical loading [8]. The degradation of these materials is attributed to the thermal shocks in the oral environment leading to the elution of leachable monomers from composites [9] or degradation of metal-polyacrylate bonds in GICs [10]. Such degradation may, in turn, cause colour changes in these materials. The behaviour and performance of dental restorative materials during clinical service, to a certain extent, can be simulated by thermocycling. During thermocycling, materials are aged by repeatedly subjecting them to temperature changes that are frequent in the oral cavity [9]. Characterization of dental restorative materials using thermocycling better simulates the clinical service life and facilitates a better understanding of their behaviour in such situations.

As Cention N offers better aesthetics along with superior mechanical characteristics, it is the most likely preferred choice of material for anterior restorations. However, the clinical success of such restorations greatly depends also on its colour stability. The existing literature on the colour stability of these materials, especially using thermocycling, is scant. Hence, the study aims to compare the colour stability by measuring various colour parameters of Cention N, Fuji IX GP Extra, and Fuji IX GP before and after 250 and 500

thermal cycles by spectrophotometric analysis. The Null hypothesis tested was that there is no change in the colour of a material before and after thermocycling and that there is no difference in the colour stability between the three materials.

Material and Methods

As total of 30 specimens (10 per group) were prepared from three restorative materials: Group I: Alkaside, Cention N (Ivoclar Vivadent, Schaan, Liechtenstein); Group II: Glass Ionomer Cement, Fuji IX GP Extra (GC Corporation, Tokyo, Japan); and Group III: Glass Ionomer Cement, Fuji IX GP (GC Corporation, Tokyo, Japan).

The preparations of the specimens were done according to the powder/liquid ratio as recommended by the manufacturers [4.6:1, 3.4:1 and 3.6:1 for the groups I, II, and III respectively]. Both the powder and liquid of the respective materials were measured by weight (Mettler AJ100, Greifensee, Switzerland) onto a paper mixing pad. The constituents were spatulated using a plastic spatula to a homogeneous paste, and the mix was forced into a split metal mold of 1 mm thickness and 10mm diameter [11,12]. The mold was covered with a mylar strip, both on top and bottom, and a load of 1 kg was applied for 5 minutes to facilitate the flow of material evenly throughout the mold. After setting, the samples were retrieved, and the thickness of each specimen was measured using a micrometer at five different locations. Subsequently, the specimens were observed under a bright light source to check for porosities, or cracks in the specimens. The specimens with variations in thickness, porosity or cracks were discarded and thus not included in the study. The selected specimens were stored in distilled water for 24 hours prior to testing [13].

Thermocycling was carried out using a thermocycler (Lab Thermostatic Bath, Jainam Lab Solutions, Mumbai, Maharashtra, India) containing water baths maintained at 5°C and 55°C. The specimens were thermocycled at these temperatures with a dwell time of 15 seconds for 250 or 500 cycles.

Measurement of the optical properties was done using i1Pro (X-Rite, Grand Rapids, Michigan, USA), a computer-controlled spectrophotometer that produces colour coordinates for the CIE LAB system. The colour measurements were taken by placing the specimen in a specimen holder followed by passing the light on to the specimen in total transmittance mode with a standard illuminant D65 and observer angle of 0°. The specimen holder was so designed to ensure that all the specimens were exposed to the light at the same place throughout the study period. The colour coordinates, L* (lightness, where 100 represents white, and 0 represents black), a* (red-green chromaticity index), and b* (yellow-blue chromaticity index) were determined against a standard white background. The ΔE , change in the colour, of the specimens was computed as follows: $\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{0.5}$, where: ΔL^* , Δa^* , Δb^* represent the change the respective values during the study. The colour of the specimens was measured at the beginning of the study, after 250 cycles and after 500 cycles of thermocycling.

Data Analysis

The data were subjected to Two-way ANOVA test to compare the mean differences between the groups at a confidence interval of 99%.

Results

The mean and standard deviation values of the colour parameters measured during the study are presented in Table 1.

Table 1. Colour parameters of various materials tested in the study.

| Colour Parameters | Group I | Group II | Group III |
|-----------------------|--------------------------|---------------------------|---------------------------|
| Base Line Measurement | | | |
| L* | 54.32 ± 1.26 | 68.44 ± 0.44 | 71.01 ± 1.07 |
| a* | 0.07 ± 0.65 | 1.24 ± 0.12 | 1.38 ± 0.18 |
| b* | 8.50 ± 0.91 | 9.82 ± 0.36 | 9.95 ± 0.68 |
| 250 Cycles | | | |
| L* | 54.44 ± 1.02 | 67.23 ± 0.57 | 69.94 ± 1.29 |
| a* | 0.27 ± 0.26 | 1.29 ± 0.12 | 1.40 ± 0.25 |
| b* | 7.79 ± 1.53 | 10.37 ± 0.30 | 9.80 ± 0.71 |
| ΔE | 1.01 ± 0.79 | 1.36 ± 0.29 | 1.32 ± 0.50 |
| 500 Cycles | | | |
| L* | 55.55 ± 1.92 | 64.89 ± 0.98 ^b | 69.02 ± 1.83 ^c |
| a* | 0.28 ± 0.44 | 1.62 ± 0.13 | 1.82 ± 0.20 |
| b* | 7.86 ± 1.08 ^a | 10.22 ± 0.36 ^b | 9.80 ± 0.67 ^c |
| ΔE | 2.15 ± 0.71 | 3.60 ± 0.84 | 2.55 ± 0.62 |

a, b, c in Group I, II and III rows indicate that the value is significantly different from the respective control value.

Table 1 indicates that thermocycling of all the materials used in the study resulted in changes in the colour, and the colour changes increased with an increasing number of cycles of thermocycling. Thermocycling did not show any significant changes in L* values in Group I either at 250 cycles ($p > 0.999$) or 500 cycles ($p = 0.409$). Group II and Group III showed a significant difference in L* values only after 500 cycles ($p < 0.001$). No significant differences in a* were observed among the groups irrespective of the number cycles of thermocycling. Groups I, II, and III showed significant changes in b* values after 500 cycles ($p < 0.001$). However, the change in b* values at the end of 250 cycles was found to be statistically not significant in all the materials.

The changes in the colour of the material as expressed in ΔE were found to be 1.01 ± 0.79 and 2.15 ± 0.71 at the end 250 cycles and 500 cycles respectively in Group I. In Group II, ΔE values after 250 cycles and 500 cycles were found to be 1.36 ± 0.29 and 3.60 ± 0.84 respectively. Group III, on the other hand, showed ΔE values of 1.32 ± 0.50 and 2.55 ± 0.62 at the end of 250 cycles and 500 cycles of thermocycling.

Discussion

The dynamic nature of the oral environment with constant changes in pH, stress, and temperature may significantly influence the colour stability of esthetic restorative materials [13]. The present study demonstrated significant changes in the colour parameters of the three materials subjected to thermocycling, especially at 500 cycles.

The luminosity of the material represented by L* is an important colour parameter as it is more likely to be perceived by human eyes than any other colour parameter [1,14]. The results of the present study indicate that the change in L* is more in the case of Glass ionomer based restorative materials, whereas no significant changes were observed with Cention N. This indicates that the colour stability of Cention N is superior to glass ionomer cements. No significant changes in a* values were observed with all the material tested, indicating no changes in the red-green axis of the colour of these materials. A significant difference b* was observed in all the groups after 500 cycles indicating changes in the yellow-blue axis. It is interesting to note that b* values changed more towards yellow in both glass ionomer cements whereas in the case of Cention N, no such change was observed.

The colour stability of Cention N can be attributed to the presence of resin components in its composition. It consists of organic liquid containing UDMA, DCP, an aromatic aliphatic-UDMA, and PEG-400 DMA along with high filler content. Such a combination permits low sorption, indicating less possible surface penetration of the chromophores and less colour change [4,15,16]. In addition, Cention N uses thiocarbamide as a photoinitiator rather than an amine. Tertiary amines are most commonly used as activators and are known to undergo oxidation with time, leading to colour changes, widely known as amine discoloration [17]. The observed colour changes in the material, though, are minimal, could be due to degradation of the polymeric matrix material, or other ingredients in the material [18]. GIC Fuji IX GP Extra and GIC Fuji IX GP lack colour stability due to polyacid content of the material and can be explained by the degradation of metal polyacrylate salts [10]. The further reduced colour stability of GIC type IX Extra could be attributed to its low powder-liquid ratio due to higher disintegration [19].






According to CIE, ΔE (colour difference) of less than or equal to 1.0 is not perceptible by the human eye, the difference of 1-2 is perceptible through close observation as seen in professionals whereas a difference of 2-10 is perceptible at a glance [6]. Several research investigations have indicated that a ΔE value of 3.3 [20] is clinically perceptible through other studies suggest ΔE values in the range of 3.7 [21] to 4.4 [22].

In the present study, ΔE values of Cention N, Fuji IX GP, and Fuji IX GP Extra were found to be 1.01 ± 0.79 , 1.36 ± 0.29 , 1.32 ± 0.50 , respectively. This indicates that the change in colour among the materials tested is clinically not perceptible. However, ΔE values after 500 cycles of thermocycling for the same materials were found to be 2.15 ± 0.71 , 3.60 ± 0.84 , 2.55 ± 0.62 respectively indicating that the colour changes are clinically perceptible. Among the materials, Cention N showed the least colour changes with the thermocycling compared to Fuji IX GP and Fuji IX GP Extra.

Conclusion

Cention N exhibits better colour stability than GIC Fuji IX GP and GIC Fuji IX GP Extra.

Authors' Contributions

| | | |
|-----|---|--|
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Conflict of Interest

The authors declare no conflicts of interest.

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