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Color Stability of Bulk-Fill Flowable Composite Vs Conventional Flowable Composite after Accelerated Aging. Comparative In-Vitro Study.

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ABSTRACT

This study was carried out to compare the color stability of two different types of resin composite after accelerated aging. Specimens of X-tra base (VOCO GmbH) bulk fill flowable composite and Grandio flow (VOCO GmbH) flowable composite were aged in a weather chamber device for 296 hours with a total energy of 300 kilojoules . Color assessments were done before and after aging. The color change was calculated from the following equation: $\Delta E= [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{½}$. Results showed significant color changes for both composite types after aging with both showing nearly equal ΔE values. It was concluded that the two types of tested resin composites lacked the ability to maintain their color after aging and that bulk fill flowable composite did not show any significant improvement regarding color stability.
Keywords: color - bulk fill - weather chamber - flowable composite

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INTRODUCTION

In the era of the tooth-colored dental restorations, color stability is one of the necessities of restorative materials. Resin composite material has witnessed great improvements over the past years. Improvements in mechanical, surface and optical properties, clinical application and performance introduced a wide variety of resin composite material. This demanded a comprehensive knowledge of the materials characteristics and performance by the dentist for more precise evidence-based selection of restorative material. Lately bulk fill resin composite materials were introduced to dentistry with an increasing number and different applications. All of them share the same claim of being able to properly cured as on bulk up to 4mm thickness.

Color stability of resin composite restorations is a prime request for successful and durable restoration. However color changes could be caused by intrinsic factors such as composition of the resin matrix including filler loading and particle size distribution, type of photo- initiator and percentage of remaining un reacted monomer or extrinsic factors as the intensity & duration of polymerization, exposure to environmental factors including UV radiation, heat, water or dietary colorants [1].

The most commonly used photoinitiator in dental composites is camphorquinone which is claimed to cause yellowing of composite with aging, the cause of composite yellowing is based on the fact that not all the photoinitiator in composite is consumed in case of incomplete curing, the residual photoinitiator decomposes with aging, causing yellowing of composite. Consumption of the photoinitiator is required to enhance polymerization reaction and the degree of conversion leading to more color stability [2].

In response to the claims of manufacturers that flowable and flowable bulk fill resin composites can be used as direct esthetic restorations in non stress bearing areas; a question was raised about the color stability of these materials.

Aim: this study was carried out to detect the effect of accelerated aging on the color stability of two types of flowable resin composites; bulk fill flowable composite and conventional flowable composite.

MATERIALS & METHODS

Two flowable composites were used, both of A2 shade:
Bulk-fill flowable resin composite: X-tra base (VOCO GmbH)
Conventional flowable resin composite: Grandio flow (VOCO GmbH)

Specimen preparation and grouping:

Specially fabricated circular split Teflon molds with metallic rings were fabricated with an internal diameter of 2 mm and 4 mm thickness. The molds were used for the fabrication of 10 resin composite disc specimens, forming two groups (5 specimens each); B1: X-tra base where one bulk of 4mm thick composite was cured for 20 seconds for each specimen & B2: Grandio flow where the 4mm thick mold was filled by two increments of 2mm thickness and each increment was cured individually.

Base line color assessment:

Baseline color assessment was carried out using a spectrophotometer (Shimadzu, UV-3101 PC Schimadza corporation, 1991). Scanning of specimens was done in reflectance mode and was performed over a wavelength range of 380-780 nm (the visible spectral range).

Colorimetric values of the specimens were determined using the Commission Internationale de l'Eclairage (CIE L* a* b* color scale). Where L* parameter determine the lightness of color i.e., high L* value denotes increased lightness while low value denotes increased darkness, a* parameter determines the red-green axis i.e., high a* value indicates increased redness, while low value denotes increased greenness, b* parameter determines the yellow-blue axis i.e., high b* value denotes increased yellowness while low value denotes increased blueness [3].

Physical aging: using the weather – Ometer apparatus to simulate the spectral output of natural daylight, the specimens were aged for 296 hours with a total energy of 300 kJ in Atlas Ci35 Fade-Ometer using xenon long arc 1400 watts with a sophisticated controlled irradiance system insuring uniform specimen exposure.

Assessment of color change:

After aging, each specimen was removed; thoroughly rinsed using distilled water and dried with filter paper. Each specimen was subjected to color measurement in the same way as the baseline. The reflectance of each sample was represented by a graph drawn by the computer of the spectrophotometer. The color change was calculated from the following equation:

$$\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{½}$$

Statistical analysis:

Data presented as mean and standard deviation (SD) values. Data explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests. Independent t-test used to compare between different tested restorative materials for mean color parameters.

The significance level was set at $P \le 0.05$.

Statistical analysis was performed with IBM® SPSS® (SPSS Inc., IBM Corporation, NY, USA) Statistics Version 23 for Windows.

RESULTS

Different between tested materials

Mean and Slandered deviation (SD) for the color parameters for different tested restorative materials presented in table (1).

Table 1: Mean and Slandered deviation (SD) for the color parameters for different tested restorative materials.

	Composite				p-value
	bulk fill Flowable composite		Conventional Flowable composite		
	Mean	SD	Mean	SD	
ΔL	-3.65	.42	-3.39	.49	0.396 NS
Δa	2.95	.34	2.75	.27	0.334 NS
Δb	1.80	.27	1.62	.22	0.273 NS
ΔE	5.05	.34	4.67	.40	0.154 NS

**= Significant, NS=Not Significant*

According to individual ability of human eye to appreciate differences in colors, three different intervals were used to distinguish changes in color values: $\Delta E < 1$ - imperceptible by the human eye; $1.0 < \Delta E < 3.3$ -considerate appreciate only for skilled person, both clinically acceptable and, $\Delta E > 3.3$ - easily observed, these color changes values are not clinically acceptable.

All tested specimen showed statistically and clinically significant color changes, with no significant differences between the two tested groups.

DISCUSSION

Currently there is growing trend among practitioners to use bulk-fill resin based composite materials because of their more simplified procedures. Manufacturer's mentioned that the main advancement of bulk-fill resin composite materials, namely increased depth of cure, which probably results from higher translucency, and low polymerization stresses are related to modifications in the filler content and/or organic matrix with the help of advanced technology [4].

Specimens were aged in a weather chamber apparatus to detect the intrinsic color change of resin composite with accelerated aging which is related to its composition and degree of polymerization. This study have demonstrated significant color changes; for both conventional and bulk-fill resin composite after storage in the weather chamber, that rendered the restorations clinically unacceptable $\Delta E > 3.3$ [5], while there was no significant difference in color between the conventional and the bulk-fill resin composites.

Polymerized resin composite have higher diffuse reflectance than unpolymerized composite resins [6]. This change indicates an increase in the refraction coefficient of the matrix phase following the conversion of monomer to polymer, whereas, the refraction coefficient of filler phases remain unchanged. In the current study, all specimens had A2 shade, conventional resin composite was applied to the mold in two layers each with 2 mm thickness, while that of the bulk-fill was applied as one layer 4 mm thickness (following manufacturer's instructions). They were then applied in the weather chamber aging device for an aging equivalent for 6 months.

This might be attributed to inadequate polymerization. A lower degree of conversion might also cause increase in the amount of released unreacted monomer, leading to color changes of restorations. Oxidation and hydrolytic degradation caused by monomer trapped in the restoration might result in discoloration and accelerated wear. In composites with a base of Bis-GMA & Bis-Ema as in Grandio flow and X-tra base flowable composites involved in our study, degree of conversion varies between 45-85%. It has been reported that in resin composite with a base of Bis-GMA, degree of polymerization is 20% lower compared to other monomers [7]. Low degree of polymerization decreases the color stability and can intensify discoloration due to release of products such as methacrylic acid and formaldehyde [8]. It was reported that the ultimate degree of conversion of different monomer systems increases in the following order Bis-GMA< Bis-EMA< UDMA<TEGDMA. Bis-EMA and TEGDMA these types of monomer highly flexible, low molecular weight, low viscosity all these properties lead to high mobility during polymerization and consequently favouring conversion [9]. This might explain that both materials showed no significant color changes differences despite X-tra base having a 4 mm cured increment compared to 2mm increment of Grandio flow. Another contributing factor that might affect the degree of conversion of resin composite is the filler particle size [10]. Degree of conversion decreased in composites whose filler particles size closer to the wavelength of the activating light. This is due to the scattering effect of fillers of this size which reduces the amount of light transmitted through the resin composite. Also intrinsic factors such as size, percentage and type of filler particles as well as type of initiator and its chemical composition affect the color stability of composites [11]. The lower the filler content the greater the color change of this composite. The light scattering produced by nanofillers may adversely affect the physical properties of nanofilled composites. The larger particles of hybrid composites have a greater depth of cure as they less affected by light scattering [12]. The bigger filler size of xtra base compared to that of Grandio flow, decrease the total filler surface and consequently the filler matrix interface is reduced allowing more light to penetrate the material and to better cure the composite in depth [13].

CONCLUSION

Within the limitation of this study, the tested two resin composites showed significant changes in optical properties after aging.

Bulk-fill flowable composite didn't differ than conventional flowable composite regarding color changes after aging.

The results of this study revealed that; the two types of resin composite used in this study Xtra-base bulk fill and Grandio are not recommended to be used in esthetic areas.

Recommendation:

Testing in a more oral simulation environment is needed to reach clinically relevant conclusion and also different light curing units to give the maximum degree of conversion which affect directly on the optical properties.

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