

Evaluation the Effect of In-Office Bleaching on Color Changes on Restorative Composite Resins

Ameer AL-Ameedee¹, Hala Ragab², Ziad Salameh³, Essam Osman⁴

¹Faculty of Dentistry, Beirut Arab University, Lebanon, Babylon University, Hila, Iraq

²Faculty of Dentistry, Beirut Arab University/Lebanon

³School of Dentistry / Lebanon University /Beirut/Lebanon

⁴Faculty of Dentistry, Beirut Arab University

Abstract: *This study evaluated the vitro performance of the effect of in-office bleaching (Zoom gel material) on the color changes of the one hundred twenty discs specimens, 5 mm in diameter and 2 mm thickness and shade color (A1).these were divided to three groups according to material which prepared from; Beautiful II (B), ISP Empress Direct (E) and Ceram.x.mono composite resins (C), each group's discs specimens were subdivided into four subgroups (n=10), according to the time follow up. All specimens' discs were polished and stored in distilled water at 37°C for one week. These specimens' discs were exposed later to four sessions of in office bleaching. The colorimetric measurements were performed at baseline (before bleaching), 48 hours after bleaching, 3 months and 6 months after bleaching. Data statistically analyzed. Results showed: there were significant effects on the different color parameters L*, a* and b* according to the CIE L* a* b* color system and color change (ΔE) on the specimens of the three contemporary composite resins materials.*

Keywords: Restorative composite color changes, in-office bleaching gel, CIE L* a* b* color system, Beautiful II composite resins, ISP Empress Direct composite resins and Ceram.x.mono composite resins.

1. Introduction

The esthetic goals of our patients and dentistry today have become increasingly demanding the use of composite resins as tooth composite resin to achieve the optical properties of natural teeth. The aesthetic appearance of anterior teeth has become a major concern for patients. Discolored vital anterior teeth have long treated with different approaches including crowns, direct and indirect veneers, composite resin composite resin, and most conservatively bleaching. Both take-home and in-office bleaching techniques have proven effective results in whitening teeth with the latter having the advantage of producing immediate results [1],[2].

The bleaching agents are able to provide tooth color change and, at the same time, may yield color and surface alterations of resin composite resin existed on teeth. The response of resin composites to the whitening materials is associated with the type, the concentration of bleaching agent and the total bleaching time the available products concerning the effect on color and on surface properties of aesthetic materials are expected, the effects of bleaching regimens on the color and gloss of resin composites had adequately investigated [3], [4], [5]. Kim et al, they revealed that tooth whitening causes negligible alterations on the color and the surface of a Nano filled and two micro-hybrid resin composites [6].

The type of the resin composite in terms of composition in organic and inorganic phase has detected as a crucial factor for the degree of color and surface alterations induced by the bleaching products [7], [8], [9], [10], [11] and [12]. Resin materials are especially more prone to chemical alteration compared to inert metal or ceramic composite resin [13], [14] and [15]. In addition, composite resins tend to discolor

teeth due to their resin matrix hydrophilicity and water absorption properties. Thus, the degree of discoloration may lead the patient and the dentist to replace composite resin composite resin over time [16]. The typical in-office bleaching regimen involves application of a high percentage hydrogen peroxide formulation either to the teeth surfaces, which activated chemically or by a light source. The theoretical advantage of using lights was their ability to heat hydrogen peroxide, thereby enhancing the rate of oxygen decomposition. The oxidation in which the molecules causing discoloration are chemically modified [17]. The increased amount of oxygen-free radicals produced thus enhances the release of stain-containing molecules and, therefore, results in enhanced whitening [18], [19].

Among many reports concerning the effects of in-office bleaching on natural teeth, and its effect on tooth-colored composite resin is not, yet, fully known. The resin composites are widely used as restorative materials because of their excellent aesthetic properties. However, their initial color may change over time because of surface and marginal staining, as well as internal material deterioration [20], [21]. Discoloration can be evaluated with various instruments. Instrumental colorimetric, used in the present investigation, can eliminate the subjective interpretation of visual color comparison [22]. In this study, color measurements were performed by stereomicroscope using the CIE (Commission Internationale de l' Eclairage) L*a*b* color system. Color measurements were assessed utilizing (L*) value. The major parameter causing the color change was found to be (L*) rather than the chroma (a* and b*) [23].

The purpose of this study was to determine the different color parameters L*, a* and b* according to the CIE L* a* b* color system and ΔE color change of three Nano filled composites when subjected to in-office bleaching technique

using Zoom gel material. The null hypothesis was that the three-nano filled composites would respond similarly to the bleaching agent.

2. Material and Methods

Three groups (n=40 discs) of resin composites specimens: Beautifil II; [Bisphenylglycidyl Dimethacrylate (Bis-GMA), 7.5% Triethylenglycol Dimethacrylate (TEGDMA), 5% Aluminofluoro, 70% Al_2O_3 (borosilicate glass). DL-Camphorquinone, (Shofu Dental Corporation, USA)]. ISP Empress Direct; [Paste of Dimethacrylates, copolymer 20-21%wt, barpum glass 77.5-79%wt, ytterbium trifluoride (550nm), Initiators, stabilizers and pigments,(Ivoclar Vivodent, USA)]. Ceram.x.mono; [methacrylate modified polysiloxane, dimethacrylate resin, Ba-Al-borosilicate glass 70%, pyrogenic SiO_2 57% , camphorquinone, ethyl-4-dimethylamino benzoate, UV stabilizer, butylated hydroxy toluene, (DeTrey, Dentsply, Germany)] composite resin specimens, these three resin composites used in this study.

Each group specimens was subdivided into four subgroups according to the time follow up (n=10, shade A1). Each disc specimen was prepared by using cylindrical Teflon mold length 2mm and width 5mm, the resin composite put as one increment, and light cure to polymerized from each side for 40 seconds using a light unit (GNATUS, Fotopolimerizador optilight plus, Brasil) with intensity of 350 mW/cm^2 ; then polished with Sof-Lex system (3M ESPE, Company). All composite resin groups' discs specimens were stored in distilled water at 37°C for one week to complete their polymerization, and then subjected to in-office bleaching for four sessions according to the manufacture instructions. The measurements recoded according to timetable as shown in Table 1.

The test measures L^* , a^* , and b^* color space and this system are referred to as CIEL*a*b*. In the color space, L^* indicates lightness ($L^*+=$ lightness and $L^*-=$ darkness), the a^* coordinate represents the red/green range ($a^*+=$ redness and $a^*-=$ greenness) and the b^* coordinate represents for the yellow/blue range ($b^*+=$ yellowness and $b^*-=$ blueness). The values of the coordinates a^* and b^* approach zero are indicating neutral colors (white and gray) and an increase in magnitude for more saturated or intense colors [24]. Color evaluation performed using a vita Easy Shade spectrophotometry which expresses color coordinates according to the CIE L^* a^* b^* color system. Other methods of color determination had been used in dentistry, including visual assessment with the instrumental methods generally considered more precise as they eliminate subjective errors [25].

More importantly, the CIE L^* a^* b^* color system is widely popular and developed for characterization of colors based on human perception. This system color difference value, ΔE is expressed as a relative color change between successive color measurements. It generally agreed that a value of $\Delta E \geq 3.3$ considered clinically perceptible [24],[25], [26], [27]. The L^* a^* b^* system allows the numeric definition of a color as well as the difference between two colors values were obtained using the Hunter's equation (Central Bureau of the International Commission on Illumination

Colorimetric CIE publication. Vienna, Austria: 1986) following formula:

$$\Delta E = [(L1 - L0)^2 + (a1 - a0)^2 + (b1 - b0)^2]^{1/2}.$$

The change in color from baseline compared to the color after 48 hours of the bleaching was calculated ($\Delta E1$). The change in color of the 3-months after bleaching compared to the color after 48 hours of bleaching was also calculated ($\Delta E2$). The change in color after 6-months of the bleaching compared to the color after 3-months was also calculated ($\Delta E3$).

2.1 Statistical Analysis

A randomly selected sample from each treatment group was used to examine color changes. This assessment was performed using a vita easy shade. The measurements data of color changes were collected, tabulated and statistically analyzed. Data were presented as mean, standard deviation (SD) which is a measure of variation between values, which is a measure values. LDE post hoc test was used for pairwise comparison between the means when the ANOVA test is significant. The significance level was set at $p = 0.05$. Statistical analysis was performed with SPSS 20.0 (Statistical Package for Scientific Studies Inc., Chicago, IL, USA) for Windows.

3. Results

3.1. The effects of bleaching on the three composite resin group's specimens discs

Where are ΔL^* , Δa^* and Δb^* values: Its color differences' in the CIE L^* a^* b^* color space;

If ΔL^*+ : means specimen after is lighter than before during time follow up.

If ΔL^*- : means specimen after is darker than before during time follow up.

If Δa^*+ : means specimen after is redder than before during time follow up.

If Δa^*- : means specimen after is greener than before during time follow up.

If Δb^*+ : means specimen after is yellower than before during time follow up.

If Δb^*- : means specimen after is bluer than before during time follow up.

If $\Delta E \geq 3$ means specimen recognizes for human eyes view.

Results showed there were highly significant differences in the CIE L^* a^* b^* color space means values for all-time follow up among the three groups composite resin specimens discs; that means there were differences on L^* a^* b^* color space among those groups.

Results showed that among all groups were significant differences $p < 0.01$ in ΔE color changes means values when compared before bleaching with 48 hours, 3months after bleaching time follow up except Ceram.x.mono was no significant; that means there was bleaching effect on these materials, as seen in table (2) and diagrams(1, 2, 3). While among all groups were no significant differences in ΔE color changes means values when compared before bleaching with 6months after bleaching time follow up except ISP Empress Direct was significant differences $p < 0.01$; that means there

was time effect on these materials, as seen in table (2) and diagrams(1, 2, 3).

Within Beautifil II and ISP Empress Direct composite resin specimens' discs, between before bleaching time follow up and 48 hours after bleaching all-time follow up of the three groups composite resin specimens discs. While only ΔE for 48 hours after bleaching showed highly significant differences in between groups; that means there were bleaching effect on these materials, as seen in table (2) and diagrams(4).

3.1. The effects of bleaching on each composite resin group's specimens discs

3.1.1. The effects of bleaching on Beautifil II (B) composite resin group's specimens discs

Tables 3, 4 and Diagrams 2, 3, 4 were showed that:

1. Results were showed highly significant differences ($P<0.01$) of the Beautifil II discs' specimens in the ΔL^* , Δa^* , Δb^* and ΔE means values ($F=47.07$, $F=45.248$, $F=28.02$, $F=398.7$ respectively) for 6-months' time follow up; that means there were an effect differences changes on L^* , a^* , b^* and ΔE of these materials (Table 3).
2. Results showed that the L^* and b^* means values; were highly significant differences decrease ($p<0.01$) mean values for before bleaching comparing with 48 after bleaching, 3 months and 6 months after bleaching; that means bleaching had an effect on mean values of this material. Results showed of the L^* and b^* means values of the Beautifil II discs' specimens decrease for time follow up: after 48 hours of bleaching, 3-months after bleaching and 6-months after bleaching.
3. Results showed that the a^* mean values of the Beautifil II discs' specimens; were highly significant differences increase ($p<0.01$) mean values for before bleaching comparing with 48 after bleaching, 3 months and 6 months after bleaching; that means bleaching had an effect on color changes (ΔE) values of this material. The a^* mean values change from negative to positive means values; that means specimens color were became redder in color than for before bleaching time follow up.
4. Results showed that the ΔE means values; were highly significant differences decrease ($p<0.01$) mean values for 48 hours after bleaching comparing with 3 months and 6 months after bleaching; that means bleaching had an effect on mean values of this material. Results showed of the ΔE means values of the Beautifil II discs' specimens decrease for time follow up: 3 months after bleaching and 6 months after bleaching

3.1.2 The effects of bleaching on ISP Empress Direct discs' specimens group (E)

Tables 5, 6 and Diagrams 2, 3, 4 were showed that:

1. Results were showed significant differences in the ΔL^* , Δa^* and ΔE means values $F=3.417$ $P=0.027$, $F=2.646$ $P=0.049$, $F=7.969$ $P=0.002$ respectively, while b^* showed no significant differences ($F=0.607$ $P=0.426$) for 6 months' time follow up (Tables 5, 6).
2. Results showed that the L^* means values were not significant among 6 months' time follow up, except before bleaching comparing with 48 after bleaching was significant differences increase ($p<0.01$); that means bleaching had an effect on mean values of this material for

that time follow up (positive increase direction in mean value), and the specimens became lighter after. While (positive decrease direction in mean value) and the specimens became darker for 3-months and 6-months after bleaching time follow up.

3. Results showed that the a^* means values was not significant among all 6 months' time follow up except before bleaching comparing with 48 after bleaching was significant differences increase ($p<0.01$) (negative increase direction in mean value); that means the specimens became greener in negative mean values and bleaching had an effect on mean values of this material for that time follow up.
4. Results showed that the b^* means values was not significant among 6 months' time follow up. (Tables 5, 6).
5. Results showed that the ΔE means values was not significant among 6 months' time follow up except before bleaching comparing with 3 months after bleaching was significant differences increase ($p<0.011$) (Tables 5, 6).

3.1.3. The effects of bleaching on Ceram.x.mono discs' specimens groups (C)

Tables (7, 8) and Diagrams (2, 3, 4) were showed that:

1. The ΔL^* , Δa^* , Δb^* and ΔE were showed no significant differences $F=0.607$ $P=0.615$, $F=0.986$ $P=0.410$, $F=0.503$ $p=0.682$ respectively except ΔE means values was significant differences $F=8.843$ $p=0.001$ in for 6 months' time follow up.
2. Results showed that the L^* , Δa^* and Δb^* means values were not significant among 6 months' time follow up; that means bleaching had no or very little effect on these means values of this material.
3. Results showed that the ΔE mean were significant differences decrease ($p=0.043$) mean values for 48 hours after bleaching comparing with 3 months after bleaching and highly significant differences decrease ($p<0.01$) comparing with 6 months after bleaching; that means bleaching had an effect on color changes (ΔE) values of this material.

4. Discussion

Discoloration of resin composite remains a major cause for the aesthetic failure of materials. Such discoloration may be caused by intrinsic and extrinsic factors. The intrinsic factors involve the discoloration of the resin material itself. Every component of resin composite material may take part in this phenomenon. To ensure excellent aesthetics, it is necessary for tooth colored restorations to maintain intrinsic color stability and resistance to surface staining. Extrinsic factors for discolorations are known to cause staining of composite restorations. [28].

The results collected in the present investigation showed these differences in color change might be related to differences in chemical composition, size, distribution of filler particles therefore a larger area of interface between partial-matrix composite, possibly making it more susceptible to discoloration. Bleaching have an effect increase means values of a^* became redness and ΔE color while decrease in L^* darker and b^* became blueness of beautify II resin composite. And for ISP Empress Direct resin composite have an effect increase means values of L^* the brightness became lightness, b^* chroma became

yellowness and ΔE color while decrease in a^* became greenness.

Finally Bleaching have an effect increase means values of L became lighter $*$ and ΔE color while decrease in a^* became greener and b^* became blueness of Ceram.x.mono resin composite. Despite increase in brightness that was evident for these composites, this parameter alone was not conclusive or decisive for description of color, since color can only be described in three dimensions. This statement is corroborated by Lim et al. [29] who concluded that; the correlation between the contents of cargo, chroma and value is moderate, despite a direct relationship between content loading, scattering coefficient and reflected light. The increase in mean ΔE values for all groups and showed a decrease in mean ΔE values during 6 months following bleaching this was supported by other studies. [30], [31], [32] and [33].

This in vitro study has several limitations. One is the lack of thermo cycling that could influence the degree of total color change. Specimens in the present investigation were not thermally cycled. Thermal cycling is an important factor that affected the color of resin composite restorations. Thermo cycling is an in vitro process for which the tested materials were subjected to large temperature extremes compatible with the oral cavity. The difference in thermal expansion coefficient or thermal conductivity coefficient between filler particles and resin matrix may result in a difference in thermal volumetric changes between resin matrix and filler particles. Furthermore, it must be mentioned that hydrolytic degradation of bonding between resin matrix and filler particles also occurred during thermal cycling as result of water absorption. It was also reported that water absorption would be accompanied by hygroscopic expansion in the resin matrix and filler phase, thereby enhancing the weakening filler-matrix interface. All these factors led to the dislodgement of filler particles and effect on color changes therefore should be considered in future research.

5. Conclusions

Based on the results obtained from this investigation, the following conclusions could be derived:

1. Bleaching have an effect increase means values of a^* and ΔE color while decrease in L^* and b^* of Beautiful II resin composite.
2. Bleaching have an effect increase means values of L^* , b^* and ΔE color while decrease in a^* of IMP Empress Direct resin composite.
3. Bleaching have an effect increase means values of L^* and ΔE color while decrease in a^* and b^* of Ceram.x.mono resin composite.
4. All parameter there were decrease in mean value with time follow up.
5. Future Scope of this Study to the use of in-office bleaching gel have enhance esthetic apparent effect on Beautiful restoration and to use (surface pre-reacted glass ionomer) technology that contains a stable phase of glass-ionomer for aesthetic and long-lasting restorations that release and recharge fluoride on other types composite resin to improve chemicals and physicals properties.

Table 1: groups' specimen's distribution for time follows up testing

Discs groups	Time follow up testing.			
	Before bleaching	After 48 hours.	After 3 months.	After 6 months bleaching
Beautiful II composite (group one, n=40)	10 discs	10 discs	10 discs	10 discs
IPS Empress Direct composite (group two, n=40)	10 discs	10 discs	10 discs	10 discs
Ceram-X.mono composite (group three, n=40)	10 discs	10 discs	10 discs	10 discs

Table 2: One-Way ANOVA test for the CIE L^* a^* b^* color system and ΔE , among the three groups composite resin specimens discs for 6-months' time follow up.

			Before bleaching	After 48 hours of bleaching	3-months after bleaching	6-months after bleaching
groups B & E & C	L^*	F-test	151.6	151.06	37.37	59.44
		P-value	P<0.01 HS	P<0.01 HS	P<0.01 HS	P<0.01 HS
	a^*	F-test	622.07	370.7	318.4	410.4
		P-value	P<0.01 HS	P<0.01 HS	P<0.01 HS	P<0.01 HS
	b^*	F-test	788.9	247.3	111.6	118.5
		P-value	P<0.01 HS	P<0.01 HS	P<0.01 HS	P<0.01 HS
between groups B&E&C	F-test ΔE		337.7		0.139	1.017
	P-value ΔE		P<0.01 HS		0.871 NS	0.375 NS

B: Beautiful II group, E: ISP Empress Direct group, C: Ceram.x.mono group.

Table 3: Descriptive statistics of ΔL^* , Δa^* and Δb^* values of Beautiful II discs' specimens (B) for 6-months, subgroups (N=10).

			Before bleaching	48 hours after bleaching	3-months after bleaching	6-months after bleaching	F-test	P-value
B	L^*	Mean	83.15	80.07	80.7	80.49	47.07	P<0.01 HS
		SD	0.508	0.0483046	0.775	0.884		
	a^*	Mean	-0.37	0.87	0.62	0.55	45.248	P<0.01 HS
		SD	0.17	0.0483046	0.362	0.314		
	b^*	Mean	20.57	15.06	15.22	15.16	28.02	P<0.01 HS
		SD	0.236	0.052	0.155	0.151		
ΔE B	Mean		6.452		0.725	0.277	398.7	p>0.01 HS
	SD		0.306		0.843	0.297		

B: Beautiful II group, E: ISP Empress Direct group, C: Ceram.x.mono group.

*same latter in same row significant differences,*different number in same Colom significant differences.

Table 4: LSD multiple comparisons in the CIE L* a* b* color in Beautiful II discs' specimens group (B), base line measurements for all 6-months' time follow up (N=10).

Measurements for all 3 months time follow up (17-18%)					
			Before bleaching& 48 hours after bleaching	Before bleaching& 3 months after bleaching	Before bleaching& 6 months after bleaching
B	L*	P-value	P<0.01	P<0.01	P<0.01
		Sig	HS	HS	HS
	a*	P-value	P<0.01	P<0.01	P<0.01
		Sig	HS	HS	HS
	b*	P-value	P<0.01	P<0.01	P<0.01
		Sig	HS	HS	HS
ΔEB				48 hours after bleaching&3 months after bleaching	48 hours after bleaching&6 months after bleaching
	P-value			P<0.01	P<0.01
	Sig			HS	HS
B: Beautiful II group, E: ISP Empress Direct group, C: Ceram.x.mono group.					

Table 5: Descriptive statistics of ΔL*, Δa*, Δb* and ΔE values of ISP Empress Direct discs' specimens group (E) for all time intervals subgroups (n=10).

			Before bleaching	48 hours after bleaching	3 months after bleaching	6 months after bleaching	F-test	P- value
E	L*	Mean	79.08	79.46	78.9	78.01	3.417	0.027
		SD	0.397	0.381	0.483	0.396		S
	a*	Mean	-2.26	-2.46	-2.18	-2.28	2.646	0.049
		SD	0.201	0.143	0.282	0.266		S
	b*	Mean	12.85	13.12	12.86	12.78	0.951	0.426
		SD	0.525	0.301	0.538	0.531		NS
	E	Mean ΔE	0.177		0.248	0.748	7.969	0.002
		SD ΔE	0.072		0.207	0.562		S
B: Beautiful II group, E: ISP Empress Direct group, C:								

Table 6: LSD multiple comparisons in the CIE L* a* b* and ΔE color in ISP Empress Direct discs' specimens (E) group among Before bleaching measurements other time intervals periods (n=10).

periods (n=10):					
			Before bleaching& 48 hours after bleaching	Before bleaching& 3 months after bleaching	Before bleaching& 6 months after bleaching
E	L*	P-value	0.048	0.340	0.709
		Sig	S	NS	NS
	a*	P-value	0.049	0.441	0.847
		Sig	S	NS	NS
	b*	P-value	0.221	0.963	0.748
		Sig	NS	NS	NS
E	P-value ΔE			0.654	0.001
	Sig ΔE			NS	S
B: Beautiful II group, E: ISP Empress Direct group, C: Ceram.x.mono group.					

Table 7: Descriptive statistics of ΔL*, Δa*, Δb* and ΔE values of Ceram.x.mono discs' specimens group (C) and for all time intervals subgroups (n=10).

			Before bleaching	After 48 hours of bleaching	Three months later	Six months later	F-test	P-value
Ceram.x.mono	L*	Mean	82.51	82.77	82.52	82.35	0.607	0.615
		SD	0.729	0.685	0.712	0.69		NS
	a*	Mean	0.3	0.26	0.24	0.24	0.986	0.41
		SD	0.125	0.052	0.084	0.084		NS
	b*	Mean	15.5	15.3	15.31	15.31	0.503	0.682
		SD	0.503	0.283	0.453	0.453		
C	Mean ΔE			0.17	0.859	0.995	7.439	0.0035
	SD ΔE			0.106	0.608	0.639		

L* COLOR SPACE FOR ALL GROUPS

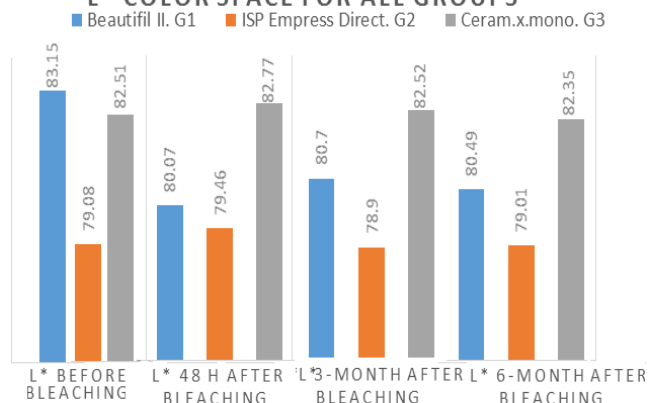


Diagram 1: L* color space for all groups for 6-months intervals

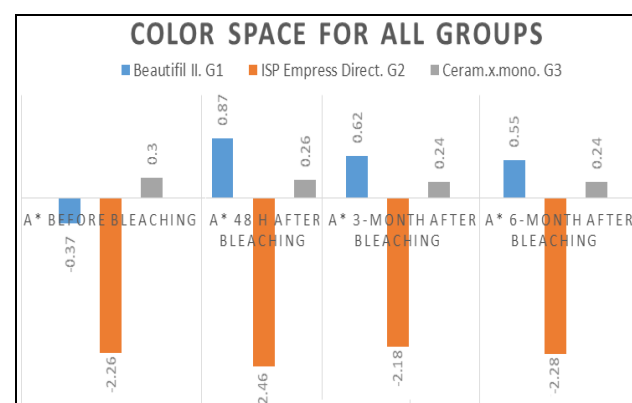


Diagram 2: a* color space for all groups for 6-months intervals.

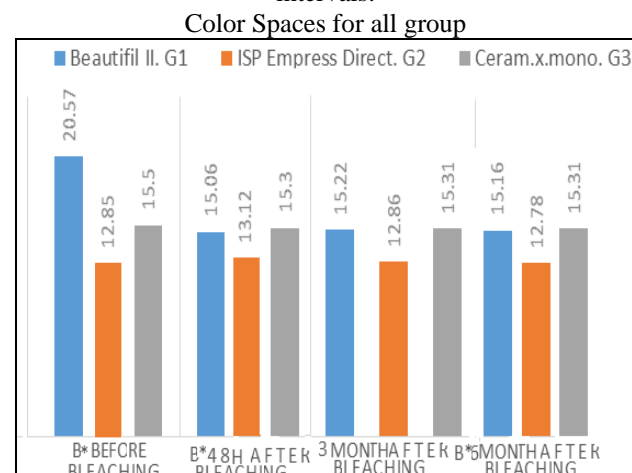


Diagram 3: b* color space for all groups for 6-months intervals.

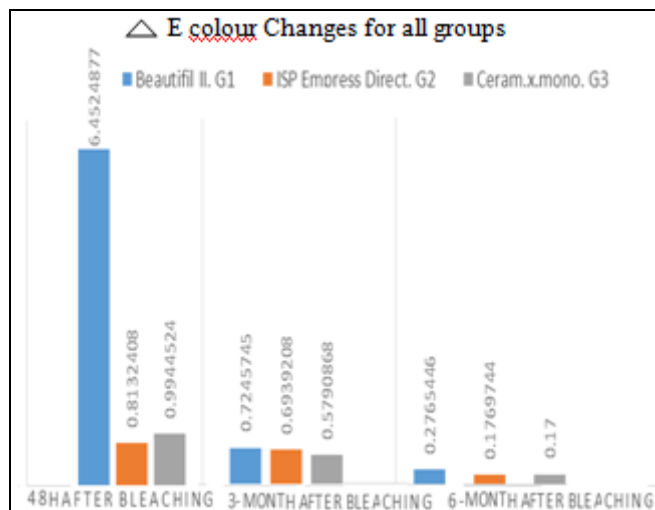


Diagram 4: color change for all composite resin groups' specimen's discs for 6-months' time follow up

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Author Profile



Ameer AL-Ameedee received the B.S. and M.S. degrees in Dentistry from College of dentistry /Baghdad University 1985 and 2005, respectively. During 1985-1996, he studied High Dental Diploma (HDD. Practical and Scientific Experience):

- 1-Training course in Prosthetic Baghdad 1986.
- 2-Training course in Computer science/ Babylon University /1996.
- 3-Training Course in Dental Implant-ology conference Baghdad 1998.
- 4- Training Course Endodontic conference Baghdad 2004
- 5- In candidate of Ph.D. Conservative Dentistry - from 2010 - to Date.