THE EFFECT OF CURING TIME AND VOLTAGE ON THE DEPTH OF CURE%OF DIFFERENT SHADES OF VISIBLE LIGHT CURE COMPOSITE RESIN, AN EXPERIMENTAL STUDY.

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Abstract

Objective: *To determine the effect of Curing Time and Voltage on 'depth of cure' of different shades of (Z -100) anterior composite restorative material.*

Materials and Methods: *An Experimental Study was conducted in the Operative Dentistry Clinic at Sardar Begum Dental Hospital, Gandhara University during the months of March and April 2018.Sample size was 90 (45 in each group) by using the calculated using a WHO calculator for health studies using the formula for hypothesis test for two population means (one-sided).Consecutive sampling technique was used to collect data. The shades (A1, A2, A3, A3.5, A4 and B1) of Z-100 dental composite system (3M ESPE, USA) will be included in the study. All shades other then these are excluded from the study. Each shade was exposed to different curing times (20s, 30s, and 40s) and variable voltage (180V, 220V). ISO scraping test was used to establish "depth of cure" for various shades. SPSS ver 17 was used for analysis*

Results: *The sample size was 90 (45 in each group). The minimum curing time was 1.86, and the maximum was 3.43 seconds with a mean and standard deviation of 2.72 and 0.43 seconds respectively. All the shades (A1, A2, A3, and A3.5 & A4) in this study passed the ISO requirement of achieving 1.5 mean depth of cure under in vitro conditions. A statistically significant difference was noticed between the mean depth of cure of various shades of composite materials at 20, 40 and 80 seconds of curing time (p-value <0.001). There was a statistically significant difference between the mean depth of cure of various shades of composite materials at 180 and 220 volts of current (p-value 0.003). There was no statistical difference between the mean curing depths of various shades of Z-100 composite materials (P-value 0.993).*

Conclusion: *This study showed that curing of different shades of composite material at different curing period and voltages significantly affect the curing depth. Change in voltage and time affects the curing depth significantly. It's important to use voltage regulator in operatory clinics where the voltage is not constant to achieve accurate curing intensity from the curing light. Once a baseline value is recognized, this technique can be used by the dentist to verify the depth of cure from time to time and to verify the work/ quality of the resin-based composite and light curing kit.*

Key Words: *Composite, curing time, depth of cure.*

Introduction

In the 1980s, hybrid composites were introduced in dentistry, commonly known as Resin Modified Glass Ionomer cement (RMGIC). The material consists of a powder containing a radio-opaque fluoro- aluminium silicate glass and a photoactive liquid contained in a capsule. The structure and composition of composite determine its physical, mechanical and aesthetic properties and the clinical behaviour. Three Basic materials form composite: the organic matrix or organic phase; the inorganic matrix, filler or disperse phase; and an organo-silane or coupling agent to bond the filler to the organic resin. The coupling agent is a molecule with silane groups at one end (ion bond to SiO_2) and methacrylate groups at the other (covalent bond with the resin)[4,7].

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The main advantages of this material are; availability of a wide range of colours and ability to mimic the dental structure, less curing shrinkage, low water absorption, excellent polishing and texturing properties, abrasion and wear very similar to that of tooth structures. Similar thermal expansion coefficient to that of teeth, universal formulas for both the anterior and posterior sector, different degrees of opaqueness and translucency in different tones and fluorescence[8,9].

During the polymerization reaction, the intermolecular distance between the Monomer molecules decreases from 3-4 Å to 1.5 Å. And this conversion determines the polymerization shrinkage or contraction[12,13]. Contraction and general effort generated in dental resins during polymerization are the main problems to deal. This, in turn, affects the integrity of the restored tooth[13]. Other disadvantages occurring because of contraction are micro-leakage, marginal discolouration, sensitivity and secondary carries[13].

Most recent studies have reported about 2% to 3% polymerization shrinkage by volume in highly filled composite resin restorative material[14,15]. 4% to 5% per volume shrinkage is reported in the flowable composite. The polymerization shrinkage is determined by the shade, opacity, and composition of the composite resin, the exposure times of the curing light used, type of photo-initiator system used and wavelength, shape of the cavity, and thickness of the composite[13,14].

When composite resins are cured, light passes through the composite attenuates, which means that deeper layers of composite resin are less cured. The factor that decreases the light intensity passing through the composite resin will lower the conversion rates as well.

-light guide distance from restoration, Intensity and wavelength of the curing light, curing mode of the composite resin, flow of the composite, water sorption of the composite[14,15].

It was this turning point in the history of dentistry that electromagnetic radiation polymerization started that decreased the overall disadvantage of composite [7]. Initially, an ultraviolet light source (365 nm) was used to provide the required light energy. The disadvantage with ultraviolet light was its shallow polymerization and iatrogenic nature. Later UV light was replaced by visible light (427-491 nm) [7,8]. Quartz tungsten halogen is one of the most widely used devices in dentistry. There is a halogen environment which contains a quartz bulb with a tungsten filament. The feature of QTH light device is that it emits both UV light and white light at same time[20]. 400nm to 500nm wavelength is suitable for QTH device to work. Its output usually ranges from 400mW/cm^2 to 800mW/cm^2.

The ISO scraping test was used to determine the depth of cure in this study as this can be performed easily in a dental office. The ISO defines "depth of cure" as 50 per cent of the length of the composite specimen after the uncured material is removed with a plastic spatula.

Inadequate light voltages and curing time may result in insufficient polymerization with poor mechanical properties and subsequent restoration failure. Although most of the dental composite manufactures suggest one optimal time for curing of all shades in a brand, there are no guidelines in term of optimal time for different shades in the same composite system. Similarly, there is not much data about the effect of the voltage of composite curing units used in the local dental practice. This study will help to establish the baseline values and perhaps alert dentists and the students about the importance of curing light voltage and time of curing for optimal polymerization of various shades of composite Z100.

Materials and Methods

An Experimental Study was conducted in the Department of Operative Dentistry at Sardar Begum Dental Hospital, Gandhara University. The study was conducted during the months of March and April 2018.Sample size was 90 (45 in each group).The sample size was calculated using a WHO calculator for health studies using the formula for hypothesis test for two population means(one-sided).Consecutive sampling technique was used for this study.

Various shades (A1, A2, A3, A3.5, A4 and B1) of Z-100 dental composite system (3M ESPE, USA) were included in the study. All shades other then these were excluded from the study.

Data collection procedure: A stainless steel ring (6mm high and 4 mm in diameter) was placed on a glass slide covered with 0.5mm thick polyester film. The Ring was filled with the sample of composite material and a second polyester film was placed on the top of the filled mould. Each sample of the composite was then cured, with the voltage of curing light set to first 180 then at 220 volts using a step up and step down transformer and verifying with a voltmeter. Each composite sample was cured for three different periods (20, 40 and 80 seconds respectively). At the end of the irradiation period, the uncured material was removed by scraping it away manually with a plastic spatula. Using a micrometre, the length of the cured specimen was measured to the nearest 0.01 mm. The depth of cure was recorded as 50% of the remaining measured length. The ISO pass/fail criterion was applied to the individual sample to determine if the cured material meets the ISO standard. This criterion requires that three samples be equal to or greater than 1.5 mm in depth.

Data Analysis: The statistical analysis program SPSS 17.0 was used for analysis. Means, frequencies, and standard deviation of quantitative variables were determined and the difference between the mean values of depth of cure of composites at different curing times at variable curing period was assessed through the Analysis of Variance (ANOVA). The mean curing depth of various shades of composites at variable voltage was assessed by Independent Sample T-test. The Level of significance was set at 0.05.

Results

A Total of 90 observations (45 in each group) were used for analysis. The mean curing time was 2.72 (SD 0.43) (min 1.86, max 3.43). All the samples (shades A1, A2, A3, and A3.5 & A4) in this study passed the ISO requirement of achieving 1.5 mean 'depth of cure' under in vitro conditions. There was a highly statistically significant difference between the mean depth of cure of various shades of composite materials at 20, 40 and 80 seconds of curing time (p-value <0.001). There was a statistically significant difference between the mean depth of cure of various shades of composite materials at 180 and 220 volts of current (p-value 0.003). There was no statistical difference between the mean curing depths of various shades of Z-100 composite materials (P-value 0.993). The mean depth of cure with 20 sec ,40 sec and 80 sec time are 2.29,2.76 and 3.09 respectively(table 1).

Table 2 shows the Analysis of variance results. The groups were made according to the curing time (20 seconds or 40 seconds or 80 seconds), the results show that there is a statistically significant difference between the curing depths of composite materials subject to various curing times. It can be inferred that at least one of the composite material group is different from others. The p-value is less than 0.001 which means that this result is highly unlikely to have occurred by chance alone.

Table 3 shows the multiple comparison (Tuckey's Honestly Significant Difference) tests. It shows that all samples are different from each other at a 5% level of significance. The p-values for 20 and 40 seconds observations was 0.002, for 40 and 80 seconds it was 0.037, and for 20 and 80 seconds, it was <0.001. Although all of these p-values are significant the difference between 20 and 80 seconds group was highly significant. The voltage variations showed that the mean curing depth of cure at 180 volts was 2.49 mm (SD 0.361mm) and at 220 volts was 2.94 mm (SD 0.38mm)(table 4). With simple descriptive analysis, it appears that samples exposed at 220 volts have a relatively higher value of mean curing depth and standard deviation. The results of Independent Samples "t" Test. it shows that the mean curing depth of composite samples exposed at different voltages (180 or 220 volts) are statistically different at 5 % level of significance (Table 5).

Table 6 describes the range and the mean curing depth of all shades of Z -100 composites in the study (A1, A2, A3, A3.5, A4 and B1) at various curing time and voltages. Each material was subjected to 18 readings

- The shade A1 had the mean curing depth (at variable curing times and voltages) was 2.72 mm with a standard deviation of 0.54.
- The shade A2 had the mean curing depth (at variable curing times and voltages) was 2.78 mm with a standard deviation of 0.42.
- The shade A3 had the mean curing depth (at variable curing times and voltages) was 2.69 mm with a standard deviation of 0.57.
- The shade A3.5 had the mean curing depth (at variable curing times and voltages) was 2.74 mm with a standard deviation of 0.31.
- The shade A4 had the mean curing depth (at variable curing times and voltages) was 2.66 mm with a standard deviation of 0.42.

The result of ANOVA revealed that there was statistically insignificant relationship between the mean curing depth of various shades of Z 100 composites (p-value 0.993) (Table 7). This showed that shade does not affect the curing depth.

Discussion

The results of this study show that all tested samples met the ISO depth-of-cure requirement of 1.5 mm when cured according to the ISO methods. All the samples (shades A1, A2, A3, and A3.5 & A4) cured at both 180 v and 220 v met the ISO standard depth of cure which comes in contrast to a study which reported that shades A3, B1, B3, C2, and C4 do not meet the ISO standard depth of cure at voltage 1801.

In our study, it is revealed that there was no statistically insignificant relationship between the mean curing depths of various shades of Z 100 composites (p-value 0.993). This comes in contrast to a study done which reported that darker shades have a shallow depth of cure as compared to lighter shades1.

Although in our study There was a statistically significant difference between the mean depth of cure of various shades of composite materials at 180 and 220 volts of current (p-value 0.003), ISO standards are met. With simple descriptive analysis, it appears that samples exposed at 220 volts have a relatively higher value of mean curing depth and standard deviation. The results this study showed that the Independent Samples "t" Test results for the mean curing depth of composite samples exposed at different voltages (180 or 220 volts) are statistically different at 5 % level of significance(p-value 0.093 and 0.100) which is similarly reported by another study also1. Also, the better depth of cure was reported by studies at 220 v[1].

In this study, there is a highly statistically significant difference between the mean depth of cure of various shades of composite materials at 20, 40 and 80 seconds of curing time (p-value <0.001). In our study the p-values for 20 and 40 seconds observations was 0.002, for 40 and 80 seconds it was 0.037, and for 20 and 80 seconds, it was <0.001. Although all of these p-values are highly significant the difference between 20 and 80 seconds group was highly significant. This comes in contrast to a study don which reported no significant differences in the Depth of Cure of RBCs that were light polymerised with different Light curing units for different times[19]. Another study reported the highest depth of cure with curing done at 60 sec and the lowest depth of cure was reported at 20-sec irradiation time[8].

Conclusion

The results of this study show that different shades of the same brand of composite material at different curing period and voltages significantly affect the curing depth. Therefore, it is important to use voltage regulators in operatory clinics where the voltage is not constant to achieve accurate curing intensity from the curing light. It is important for composite manufacturers and dentists to establish specific curing time for the each shade of composite used in the dental clinics and hospital for most effective polymerization.

Insignificant relationship between the mean curing depth of various shades of Z 100 composites (p-value 0.993) (Table 7). This showed that shade does not affect the curing depth.

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Table 1: Descriptive of observations according to curing time Outcome: 50% of the mean depth of cure (Dependent variable)

	N	Mean	Std. Dev	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
20 seconds	30	2.29	0.290	0.091	2.08	2.50	1.86	2.73
40 seconds	30	2.76	0.314	0.099	2.54	2.99	2.40	3.18
80 seconds	30	3.09	0.234	0.074	2.93	3.26	2.78	3.43
Total	90	2.72	0.432	0.078	2.55	2.88	1.86	3.43

Table 2: ANOVA test Outcome: 50% of the mean depth of cure (Dependent variable)

	Sum of Squares	Df	Mean Square	F	P-value
Between Groups	3.268	2	1.634	20.549	0.000
Within Groups	2.147	27	0.080		
Total	5.414	29			

Table 3: Multiple Comparisons: Tukey's HSD Dependent Variable: 50% of a mean depth of cure

curing time in seconds	curing time in seconds	Mean Difference	Std. Error	p-value	95% Interval	Confidence
20 seconds	40 seconds	-0.473(*)	0.126	0.002	-0.786	-0.160
	80 seconds	-0.804(*)	0.126	0.000	-1.116	-0.491
40 seconds	20 seconds	0.473(*)	0.126	0.002	0.160	0.786
	80 seconds	-0.330(*)	0.126	0.037	-0.643	-0.018
80 seconds	20 seconds	0.804(*)	0.126	0.000	0.491	1.116
	40 seconds	0.330(*)	0.126	0.037	0.018	0.643

* The mean difference is significant at the 0.05 level.

Table 4: Descriptive Statistics of Observations according to Voltage

Outcome or dependent variable	Voltage	N	Mean	Std. Deviation	Std. Error Mean
50% of a mean depth of cure	180 volts	15	2.499	0.361	0.093

Table 5: Independent Samples Test

		F	P value	T	Df	P-value	Mean Diff	95% CI	
50% of a mean depth of cure	Equal Variance Assumed	0.034	0.85	-3.22	28	0.003	-0.442	-0.723	-0.161
	Equal Variance Not assumed			-3.22	27.84	0.003	-0.442	-0.723	-0.161

Table 6: Descriptive Statistics of Composites Shades.
50% of a mean depth of cure

	N	Mean	Std. Dev	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
A1	18	2.72	0.541	0.221	2.15	3.28	1.86	3.36
A2	18	2.78	0.422	0.172	2.33	3.22	2.16	3.36
A3	18	2.69	0.570	0.232	2.09	3.29	2.05	3.43
A3.5	18	2.74	0.311	0.127	2.41	3.07	2.40	3.15
A4	18	2.66	0.422	0.172	2.21	3.10	2.00	3.16
Total	90	2.72	0.432	0.078	2.55	2.88	1.86	3.43

Table 7: ANOVA Table for Composites Shades.
Outcome: 50% of a mean depth of cure (Dependent variable).

	Sum of Squares	Df	Mean Square	F	p-value
Between Groups	0.049	4	0.012	0.058	0.993
Within Groups	5.365	25	0.215		
Total	5.414	29			