Original Article

Evaluation and Comparison of Coefficient of Thermal Expansion of Esthetic Restorative Materials

Coefficient of Thermal Expansion of Esthetic Restorative Materials

Zartashia Arooj[1], Varda Jalil[4], Shahlisa Hameedi[5], Anila Errum[2], Marryam Riaz[3] and Aneela Amjad[6]

ABSTRACT

Objective: This study was performed to compare the co-efficient of thermal expansion of three esthetic restorative materials.

Study Design: Experimental Study

Place and Duration of Study: This study was conducted at the PCSIR, Lahore from April 2015 to September 2015 for a period of six months.

Materials and Methods: A thermodilatometer was used to measure CTE at temperature range 25-70°C under both dry and wet conditions. 40 study blocks of specified dimensions of each restorative material i.e. a flowable composite, a resin modified glass ionomer cement and a compomer and were randomly divided into two groups of twenty tested in dry and wet atmospheric conditions respectively.

Results: Results obtained were that under dry and wet conditions, at temperature range 25-50°C the mean CTE value of all the three restorative material differed significantly. Resin modified glass ionomer was observed to have different pattern from the group tested under dry conditions it did not undergo contraction it showed expansion and its values were closest to tooth structure as compared to other two materials.

Conclusion: Flowable composite and Compomer both showed expansion as similar in dry and wet.

Key Words: Thermal Expansion, Restorative Materials, Tooth Tissue.

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INTRODUCTION

Temperature extremes inside the oral cavity may affect the adhesive bonding between the tooth and restorative material in the long run (Majety and Pujar., 2011)[1]. When temperature of a material is raised it expands due to molecular vibrations (Karch, 2014)[2]. If the expansion of restorative material and tooth structure mismatch the adhesive bond between tooth and restorative material will be broken and hence failure of restoration (Lohbauer et al., 2009)[3]. For long clinical life of a restoration the value of CTE should closely match that of tooth structure (Powers et al., 1979)[4].

[1.] Department of Science of Dental Materials / Pharmacology[2] / Physiology[3], Azra Naheed Dental College, Superior Group of Colleges, Lahore.
[4.] Department of Oral Pathology / Community Dentistry[5], Avicenna Medical and Dental College, Lahore.
[6.] Department of Oral Medicine, Sharif Medical and Dental College, Lahore.

Correspondence: Dr. Zartashia Arooj, Assistant Professor, Department of Science of Dental Materials, Azra Naheed Dental College, Superior Group of Colleges, Lahore.
Contact No: 03339762363
Email: zarrtashia@hotmail.com

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A variety of tooth colored materials and their modifications have been introduced in order to produce a material which is closest to tooth structure in properties.

The chemical nature and structural formula have a strong impact on thermal properties of composite material, these materials have high CTE when compared to values of tooth structure (Narsimha, 2011)[5].

Flowable composites have improved handling properties and its viscosity allows it to closely adapt to tooth structure (Prabhakar et al., 2003)[6]. The flowable composites have higher polymerization shrinkage, coefficient of thermal expansion and inferior mechanical properties. Higher polymerization shrinkage may lead to disruption of adhesive bond finally leading to microleakage (zartashia et al. 2019)[7]. For GICs no or negligible change in dimensions occur between 20˚C and 50˚C in wet environment (McCabe et al., 2011)[8]. GICs have porous structure which resulted in gain or loss of loosely bound water and the dimensional changes were compensated (Mc cabe et al., 2011)[8]. Resin-modified glass ionomers (hybrid) are used for restorations in low stress-bearing areas and for patients with high caries risk. (Sakaguchi and Powers, 2012a)[9]. They follow the same trends when heated in dry environment as conventional GICs but when heated in wet environment they expand owing to their HEMA content which has highest affinity for water and thus absorb water from surrounding environment (Yan et al., 2007)[10]. Compomers are light activated to cause setting by polymerization (Jedynakiewicz and Martin, 2001)[11]. The thermal expansion behavior of compomers is close to resin composite material (Sidhu et al., 2004)[12]. CTE of the restorative material and tooth structure should have close possible values to avoid microleakage and disruption of the adhesive seal (S.K.Sidhu et al; 2004)[12]. When the adhesive seal between restorative material and tooth structure is disturbed clinical life of the restorative material is affected (Didron et al., 2013)[13]. The materials with higher values of CTE expand more than tooth tissue on increasing temperature while materials with values closer to tooth tissue are more compatible with tooth tissue (Sakaguchi and Powers, 2012)[9].

MATERIALS AND METHODS

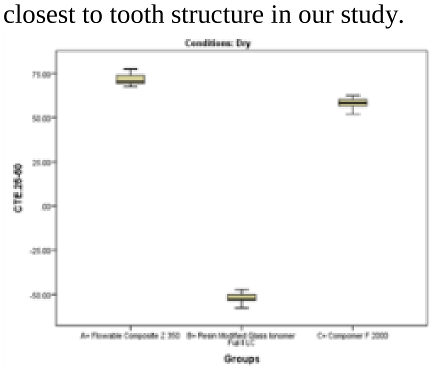
Three tooth colored materials were used. The dimensions of specimens were according to the specifications of the dilatometer used in the study. The flowable composite Filtek ™ Z350 XT Flowable restorative (3M ESPE Dental 3M ESPE Dental Products. St. Paul, Mn.U.S.A). The Resin Modified Glass Ionomer Cement, FUJI II LC(GC Corp,Tokyo Japan)and a Compomer; F2000 Compomer Restorative (3M ESPE Dental Products. St .Paul ,Mn.U.S.A)

It was experimental study with purposive sampling. Total specimens were 120 as calculated by sample size formula. Forty specimens of each restorative materials were made. They were named as flowable composite (FC) GROUP A, Resin modified glass ionomer cement (RMGIC) GROUP B, Compomer(Co) GROUP C. 20 specimens from each material were tested under dry conditions and 20 were tested under wet conditions.

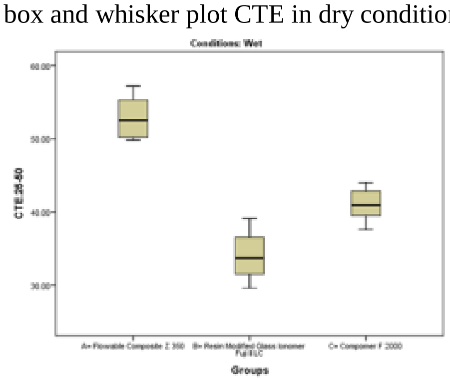
Each specimen was manually prepared with the dimensions 25mm×10mm×2mm. Dimensions were prepared by pouring the material into an open-ended stainless steel mould and light cured. Specimen was then removed from the mould and the previously unexposed surfaces were cured for 40 seconds each. The specimens were stored in distilled water for 24 hours before testing in dilatometer. The specimens of each material were further divided into two groups: group 1 & 2 each having twenty specimens. Specimens from all three materials from group 1 were tested in dry conditions and those from group 2 were tested under wet conditions. Distilled water was injected into the cotton. This ensures that these specimens were tested under wet conditions to simulate saliva rich environment of oral cavity. Specimens from each group were placed in Thermo-dilatometer (model 2016 STD, ORTON USA). Each specimen was introduced to this device for two times. The temperature was raised from 25°C to 70°C at a slow rate of 5°C/ min. Any dimensional changes in specimen were transmitted to the probe that was connected to LVDT–transducer, which allowed vertical movement of the probe to be monitored on y-axis of the recorder. Temperature variations were recorded on x-axis. CTE was measured using heating rate of 5˚C/min. CTE from second run was considered to obtain final results. While calculating the results the temperature was divided into two: 25-50℃ and 50-70℃. The values of CTE were obtained from software of dilatometer. All the collected data was entered in Statistical Package for Social Sciences (SPSS) version 18. ANOVA Tukey's pair wise comparisons of mean CTE of three restorative materials was done. A P-value < 0.05 was considered as statistically significant.

RESULTS

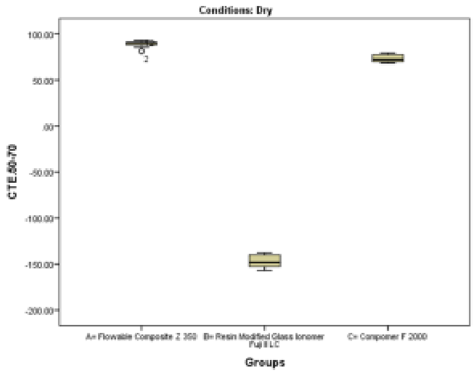
In dry conditions at 25-50°C and 50-70°C highest CTE value was seen for FC followed by Co and RMGICs. In wet conditions mean CTE value of all 3 restorative material differ significantly. In the temperature range from 25 to 50°C the FC showed expansion but the values were lower as compared to dry values. It was followed by compomer which also showed expansion, but it was lower as was shown in dry conditions. RMGIC was observed to have different pattern from the group tested under dry conditions it did not undergo contraction it rather showed expansion, but values were lowest as compared to other two materials and closest to tooth structure as compared to other two materials. In higher temperature range, 50 –70°C expansion was found in all three materials. The mean values for CTE in higher temperature range in wet conditions were closest to tooth structure in our study.



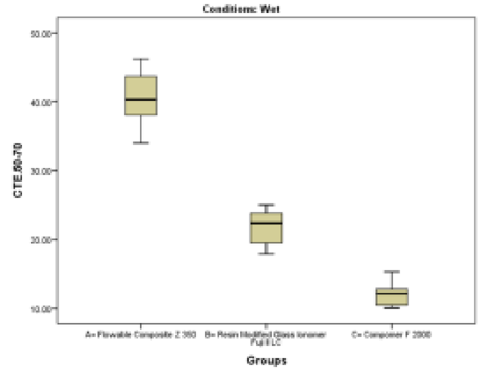
box and whisker plot CTE in dry condition at 25-50°C



box and whisker plot CTE values in wet condition at 25-50°C.



Box and whisker plot CTE values for in dry condition at 50-70°C



Box and whisker plot for CTE values for in wet condition at 50-70°C.

Table No.1: Comparison of CTE in Restorative Materials in Dry Condition at 25°-70°C

temperature	Groups	Mean± SD	Minimum	Maximum	p-value
DRY 25-50	A=FC Z 350	71.28±3.02	67.50	77.40	0.000
	B=RMGICFuji II LC	-52.36±2.92	-57.80	-47.30	
	C=Com F 2000	58.13±2.94	51.90	62.50	
DRY 50-70	A=FC Z 350	89.17±3.36	81.20	93.00	0.000
	B=RMGICFuji II LC	-147.58±6.64	-157.10	-137.80	
	C=Compomer F 2000	73.17±3.78	68.50	79.20	

Table No.2: Multiple Comparison Test to See the Difference of CTE in Between Restorative Material

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	p-value
CTE.25-500C	A=F C	B= RMGIC	123.64 (*)	0.000
		C= Comp	13.15 (*)	0.000
	B= RMGlC	A=FC	-123.64 (*)	0.000
		C= CoMP	-110.49 (*)	0.000
	C= Comp	A=FC	-13.15 (*)	0.000
		B=RMGIC	110.49 (*)	0.000
CTE.50-700C	A=FC	B= RMGIC	236.75 (*)	0.000
		C= Comp	16.00 (*)	0.000
	B= RMGIC	A=FC	-236.75 (*)	0.000
		C= Comp	-220.75 (*)	0.000
	C= Compomer	A=F C	-16.00 (*)	0.000
		B= RMGIC	220.75 (*)	0.000

Table No.3: Comparison of CTE of Restorative Material on Wet Condition

Atmosphere	Groups	Mean± SD	Minimum	Maximum	p-value
Wet (25-500C)	A= Z 350	52.96±2.86	49.80	57.20	0.000
	B= Resin Modified Glass Ionomer Fuji II LC	34.11±3.04	29.60	39.10	
	C= Compomer F 2000	40.94±2.03	37.60	44.00	
Wet (50-700C)	A=Flowable Composite Z 350	40.81±3.67	34.00	46.20	0.000
	B= Resin Modified Glass Ionomer Fuji II LC	21.83±2.39	17.90	25.00	
	C= Compomer F 2000	12.09±1.56	10.10	15.30	

Table No. 4: Multiple Comparison Test to See the Difference of CTE in Between Restorative Material

Dependent variable	(I) Groups	(J) Groups	Mean Difference (I-J)	p-value
CTE.25-500C	A=Flowable Composite	B= Resin Modified Glass Ionomer	18.85 *)	0.000
		C= Compomer	12.02 (*)	0.000
	B= Resin Modified Glass	A=Flowable Composite	-18.85 (*)	0.000

		C= Compomer	-6.83 (*)	0.000
	C= Compomer	A=Flowable Composite	-12.02 (*)	0.000
		B= Resin Modified Glass Ionomer	6.83 (*)	0.000
CTE.50-700C	A=Flowable Composite	B= Resin Modified Glass Ionomer	18.98 (*)	0.000
		C= Compomer	28.72 (*)	0.000
	B= Resin Modified Glass Ionomer	A=Flowable Composite	-18.98 (*)	0.000
		C= Compomer	9.74 (*)	0.000
	C= Compomer	A=Flowable Composite	-28.72 (*)	0.000
		B= Resin Modified Glass Ionomer	-9.74 (*)	0.000

DISCUSSION

The response of restorative materials to varying thermal stimuli do affect the long term clinical stability of the restorative material in the mouth (M.B. Lopes et al; 2012)[14]. Ideally the thermal expansion should be low to maintain an adequate bond between tooth and restoration to ensure long clinical life of a restoration. The extent of dimensional changes in a material in response to temperature variations are measured as coefficient of thermal expansion of that material (Santos et al; 2008)[15]. It is a fractional change and is given as a coefficient per unit of temperature. CTE of the restorative material and tooth structure should be as close as possible. (S.K.Sidhu et al; 2004[12], Powers et al; 1979[4], A. Tezvergil et al[16]). Microleakage can be avoided if two materials have almost same rate of contraction and expansion (Tolidis et al., 2012[17], Bullard et al., 1988[18]).

This study is performed in sequel to our previous study which was conducted to evaluate coefficient of thermal expansion of composites with low filler content (flowable composites) under both dry and wet conditions and it was concluded that CTE of flowable composites was at great variance with tooth structure due to its lower filler content which can affect its clinical stability as a restorative material (Zartashia et al., 2019)[7]. In present study we compared the effect of temperature changes on three esthetic restorative materials.

Sanbir K. Sidhu in his study assessed the Coefficient of Dimensional Change (CDC) of tooth-colored restorative materials. Similar pattern of thermal expansion was observed for all materials except for conventional glass ionomer cements which showed contraction (Sidhu et al., 2004)[12]. A study was conducted by Lopes et al in 2012 in which CTE of human and bovine teeth was compared. When tested under dry environmental conditions both human and bovine teeth showed contraction. (Lopes et. al.,)[14]. A research was carried out by Sindhu et al in 2004[12] in which he measured the values of thermal expansion of tooth colored filling materials and mentioned that temperature changes may bring about expansion of material by not merely by expansion or contraction of the materials but there may be a role of fluid content in dimensional changes of few materials.

In present study, the values of CTE of flowable composites were found to be highest amongst the three materials when tested in dry and wet conditions as well as compared to tooth structure. These higher values may be attributed to low filler content of these materials. Many studies have tested this fact. Different factors affect the CTE of these materials as mentioned in previous research work i.e. ratio of filler particles to resin matrix, bonding between fillers and resin matrix and extent of polymerization (Sidhu et al., 2004[12]; Sideridou et. al. 2004)[19]. CTE is inversely proportional to filler content.

It was previously mentioned by Yan et al in 2007[10] that RMGICs when heated in dry conditions showed greater contraction in higher temperature range i.e. above 35°C. Same pattern was observed in this study. Another study by Tolidis et al in 2013[16], where dilatometer was used to measure the CTE of three different types of glass ionomers a conventional, a resin modified and a one with modified polyacrylic acid in temperature range of 20-60°C. The result of this study was that RMGIC showed expansion when temperature was increased.

CONCLUSION

CTE of three dental esthetic restorative materials; the flowable composite, compomer and resin modified glass ionomer cement was observed. Flowable composite and compomer showed expansion under both dry and wet conditions. The behavior of resin modified glass ionomer was similar to the other two materials under wet condition, while it showed contraction under dry conditions. Under dry conditions none of the materials have CTE close to dentin and enamel while under wet conditions values of RMGIC and Compomer are closer to tooth tissue.

Co-efficient of thermal expansion is a single property, many other properties define the behavior of a restorative material and effect microleakage and hence clinical longevity of a restorative material. To prefer a material a clinician must keep other factors in mind and choose most appropriate material to ensure clinical longevity.

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Author's Contribution:

Concept & Design of Study:	Varda Jalil, Zartashia Arooj
Drafting:	Varda Jalil, Shahlisa Hameedi
Data Analysis:	Anila Errum, Marryam Riaz, Aneela Amjad
Revisiting Critically:	Zartashia Arooj, Varda Jalil
Final Approval of version:	Zartashia Arooj

Conflict of Interest: The study has no conflict of interest to declare by any author.

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