TEMPERATURE DEPENDENT DIMENSIONAL CHANGES OF COMPOSITES WITH LOW FILLER CONTENT

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Abstract

Objective: *The aim of this study was to evaluate coefficient of thermal expansion of composites with low filler content(flowable composites) under both dry and wet conditions and compare them with standard values of tooth structure.*

Materials and Methods: *The material used is flowable composite Filtek ™ Z350 XT Flowable restorative (3M ESPE Dental 3M ESPE Dental Products.St .Paul ,Mn.U.S.A).*
Forty specimens were prepared of 25mm ×10mm×2mm dimensions and divided into two groups of twenty each. Group A1 was tested under dry conditions in temperature range 25°C to 70°C and Group A2 was tested under wet conditions in temperature range 25°C to 70°C in a dilatometer. The dimensional changes were measured by the probe and CTE was collected from dilatometer under both dry and wet conditions.

Results: *CTE of flowable composites was very high when compared to standard values of tooth structure owing to lower filler content. Anova analysis give p value (0.000).*

Conclusion: *The results of this study show that values of CTE of flowable composites is very high as compared to tooth structure under both dry and wet conditions which may limit its uses. Co-efficient of thermal expansion is a single property, many other properties define the behaviour of a restorative material and effect microleakage and hence clinical longevity of a restorative material.*

Keywords: *coefficient of thermal expansion, flowable composite, dilatatometer*

INTRODUCTION

The intake of hot or cold food brings about temperature changes in oral cavity. The temperature of oral cavity by ingestion of hot and cold food was found to be around 70°C maximum and 0°C minimum (Barclay et al., 2005 ; Palmer et al., 1992). When temperature of a material is raised the molecular vibrations are also increased. This leads to expansion of a material with increasing temperature). When temperature of a material is raised the molecular vibrations are also increased. This leads to expansion of a material with increasing temperature. (Karch, 2014). The variation in oral temperatures

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leads to changes in dimensions of restorative materials. If there is great difference in dimensions of tooth and restorative material the adhesive bond breaks due to microleakage and clinical life of restoration is decreased.

In order to have a long term clinical stability the CTE of tooth structure and restorative materials should have close values so as to maintain the adhesion and avoid microleakages (Powers et al., 1979). COMPOSITES were introduced in the market as unfilled resin and formerly were used only as dental adhesives and for filling purpose in anterior teeth (Randall and Wilson 1999., Upadhyay et al 2006). Requirements of materials with improved strength, reduced polymerization shrinkage and improved hardness lead to restorative materials with improved resin matrix and with incorporated filler particles. The properties and clinical characteritics of a composite are greatly influenced by their structure (Garcia et al., 2006). Different types, compositions and shapes of filler particles have been used. Silicon dioxide, silicates are used in routine. Fillers beneficially modify the properties of a composite resin by increasing the modulus, CTE and reducing the polymerization shrinkage. (Cramer et al; 2011) Flowable composites are latest materials with improved handling properties and its viscosity allows it to closely adapt to tooth structure (Prabhakar et al., 2003). Flowable composites (FC) have low filler content resulting in less viscous material. Flowable Composites are esthetically good, have low viscosity so they are easily adaptable, clinical easy to handle and have good wetting (Majety and Pujar, 2011; Sadeghi et al., 2012). Lower viscosity brings about the advantage of improved adaptability as there is an increased flow (Didron et al., 2013). The flowable composite resins due to their lower filler content have higher polymerization shrinkage, coefficient of thermal expansion and inferior mechanical properties. They are indicated in orthodontics for bonding of orthodontic brackets, for lining deep cavities, as pit and fissure sealants, class-V restorations, for repairing fractured or chipped off restorations (Margolis, 2011., Attar et al., 2003). When flowable composites are used as preventive restorations, their low viscosity is a benefit in extending the restoration into adjacent fissures as a sealant (Sakaguchi and Powers, 2012a).

MATERIALS AND METHODS

The dimensions of specimens were according to the specifications of the dilatometer used in the study.The flowable composites are used Filtek ™ Z350 XT Flowable restorative (3M ESPE Dental 3M ESPE Dental Products.St .Paul ,Mn.U.S.A). The composition of matrix is bis-GMA, UDMA, TEGDMA, bis-EMA resins And the fillers are silica ,zirconia ,zirconia/silica aggregates. The study was experimental study. The sampling technique used in the study was purposive sampling. Total specimens were 40 as calculated by sample size formula. Specimens were divided into two groups each of 20. GROUP A1 tested under dry conditions in temperature range of 25 to 70 and group A2 tested under wet conditions in temperature range 25 to70 .

Specimen preparation

Forty specimens of flowable composite were prepared according to the dimensions mentioned in specifications of the dilatometer used in this study. Each specimen was manualy prepared having the dimensions 25mm×10mm×2mm dimensions. they were prepared by pouring the material into an open ended stainless steel mould fig.1. The top and bottom surfaces of the mould were covered with glass slides. All exposed surfaces of a each specimen were light cured for 40 seconds each. For light curing the visible light curing unit DB -685 Super (foshan COXO medical instrument Co.,ltd) was used. The light curing was done by keeping the light at a distance of 2mm from the specimen. This light cure source consisted of 6W (1200 Mw/cm2)LED power source which emitted radiation in 440-580 nm range. The diameter of light guide was 8mm. Specimen was then removed from the mould and the previously covered/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 and group 2 each having twenty specimens and Specimens from afrom group 1 were tested in dry conditions and those from group 2 were tested under wet conditions

Dry conditions

twenty specimens were grouped as A1 and were tested under dry conditions. Their temperature was raised from 25°C to 70°C and CTE was determined by calculating the temperature in two temperature

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ranges 25 to 50 and 50 to 70 using dilatometer. Each specimen was introduced to this device for two times

Wet conditions

Twenty specimens were grouped as A2 AND TESTED UNDER wet conditions

After 24 hours of storage in distilled water each specimen from group two was surrounded by thin layer of moist cotton the top surface where probe is placed was left uncovered.the lower surface was also left uncovered in order to ensure proper placement of the specimen. Distilled water was injected into the cotton before specimen testing. This ensures that these specimens were tested under wet conditions. Specimens were placed in dilatometer (model 2016 STD, ORTON USA). Each specimen was introduced to this device for two times. After 1st heating cycle the device was cooled. Each specimen was held vertically in holding chamber. With a constant compression load of 4g was applied to specimen to hold the specimen in place. 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. mulate saliva rich environment of oral cavity.

RESULTS

In dry conditions , in the temperature range 25-50°C the mean value of Coefficient of Thermal Expansion . The values obtained were 71.28±3.02. Similarly at temperature 50-70°C in dry conditions mean CTE was higher in value. The mean value for flowable composite 89.17±3.36 . This shows the expansion was greater in higher temperature range. The values were very high when compared with the standard values of tooth structure.

In wet conditions the results obtained were different. In the temperature range from 25 to 50°C the flowable composite showed expansion but the values were lower as compared to dry values. The values for flowable composite in lower temperature range were found to be 52.96±2.86. In higher temperature range, 50 –70°C expansion was found in all three materials .the mean values with standard deviations for the materials were found to be 34.11±3.04 for flowable composite. Anova analysis was done and p value was significant i.e less than 0.001.

Table 1: Values of CTE in dry conditions

Atmosphere	Group	Mean± SD	Minimum	Maximum
Dry (25-500C)	A1=Flowable Composite Z 350	71.28±3.02	67.50	77.40
Dry (50-700C)	A2=Flowable Composite Z 350	89.17±3.36	81.20	93.00

Table 2: Value of CTE in wet conditions

	Groups	Mean± SD	Minimum	Maximum
Wet (25-500C)	A=Flowable Composite Z 350	52.96±2.86	49.80	57.20
Wet (50-700C)	A=Flowable Composite Z 350	40.81±3.67	34.00	46.20

DISCUSSION

Intake of hot and cold foods brings variations in intraoral temperatures.. The response of restorative materials to these varying thermal stimuli effect the long term clinical stability of the restorative material in the mouth (M.B. Lopes et al; 2012 ; kwon et al). the interface between the tooth and restorative material is effected by number of factors, CTE being the important one. The differences in values of CTE of tooth structure and restorative material leads to breakage of adhesive bond leading to microleakage and thus failure of restoration (Sidhu et al.,2004). The CTE of a restorative material should be as close to tooth tissue as possible in order to have a long clinical life (Sidhu et. al; Sideridou et al., 2004).

CTE of dental restorative materials have been calculated and documented in various studies(Powers et al., 1979; Kwon et al., 2012;versluis et al 1996;powers et al 1979;tolidis et al 2013;mucci et al 2009; tezvergil et al 2003; santos et al 2008; sidhu et al 2004;yan et al 2007; Sideridou et al 2004). Different methods have been used to calculate CTE each having its own limitations and complexities for example Thermal mechanical analysers, strain

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gauges, dilatometers(Powers et al 1979; Tolidis et al 2013; Santos et al 2008).

The study was carried out to measure the CTE esthetic restorative materials, the flowable composite. Dilatometer was the device which was used to measure the CTE in temperature range of 25-70°C under both dry and wet conditions. The values were compared to standard values of CTE of tooth tissue. This experimental study was designed to find difference in values of CTE under two different environmental conditions.

In present study, the OBTAINED values of CTE of flowable composites were found to be very high as compared to tooth structure UNDER BOTH DRY AND WET CONDITIONS. These higher values may be attributed to low filler content of these materials. Many studies have tested this fact that amount of filler content has its effect on properties of a composite material. Different factors effect 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; Sideridou et. al. 2004). CTE is inversely proportional to filler content.

More importantly, it becomes of prime importance if it is at great variance with that of tooth tissue. Other investigators reported an initial decrease in the CTE in resin composites after the first heating which was thought to be due to secondary cure and shrinkage in the resin.7 These thermal changes are more common at higher temperatures. Vaidyanathan J, Vaidyanathan TK, Wang Y, Viswanadhan T. Thermoanalytical characterization of visible light cure dental composites. J Oral Rehabil 1992;19:49—64

A study was carried out in which thrmal expansion coefficient was measured for particulate filler composite(PFC) and fiber-reinforced composites(-FRC). PFC with low filler content (SI) had higher LCTE values than PFC with higher filler content (ZO) and (SR) having no fillers showed the highest expansion values.

CONCLUSION

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.

RECOMMENDATIONS

Flowable composite is only recommended in situation where its adaptability, flow and easy handling are of benefit and its inferior mechanical properties high polymerization shrinkage and high coefficient of thermal expansion can be ignored.

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