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THE EFFECT OF THERMOCYCLING TEST ON THE DIAMETRAL TENSILE STRENGTH VALUE OF BULK FILL RESIN COMPOSITE

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ABSTRACK

Background:*. Bulk fill resin composite can be applied and light-cured to depths of 4 mms at once. Varying temperature changes in the oral cavity that caused by the comsumption cold or hot food and beverage may cause stress on the resin composite material resulting in restoration failure. Temperature changes at 5°C and 55ºC may decrease the mechanical properties of resin composite, one of which is the diametral tensile strength.* ***Purpose:*** *to analyze the thermocycling test effect using 1500 and 3000 cycles to the diametral tensile strength value.* ***Method:*** *This study was purely experimental post test-only with control design. Twenty four bulk fill resin composite samples were divided into 3 groups, which are control group didn't tested thermocycling, second group treatment were tested thermocycling 1500 cycles and third group were tested thermocycling 3000 cycles.Diametral tensile strength was tested with universal testiimg machine and analyzed by One Way Annova.* ***Result:*** *mean value of diametral tensile strength bulk-fill resin composite of control group 42.35± 4.08 MPa, group thermocycling 1500 cycles 42.25 ± 2.26 MPa, and group thermocycling 3000 cycles 39,98±1.84 MPa. there are no significant difference in diametral tensile strength values of bulk-fill resin composite between thermocycling test group and control group.* ***Conclusion:*** *Thermocycling test 1500 cycle and 3000 cycles to composite resin not altered the diametral tensile strength value.*

Keywords*: bulk fill resin composite, diametral tensile strength, thermocycling test.*

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INTRODUCTION

Composite resin has been commonly used in dentistry as a direct and indirect restoration of anterior and posterior teeth due to their excellent aesthetic, physical and mechanical properties.[1,2,3,4,5,6] Along with the increasing development of composite resin technology has also undergone many development. One of the latest developments of composite resin is bulk fill composite resins. The bulk fill composite resin can be light-cured to a depth of 4 mm in one application especially in the posterior area due to considering higher physical and mechanical properties to withstand large mastication loads and to minimize application time in the clinic compared to conventional composite resins that requires curing with a thickness of 2 mm.[7,8]

Bulk-fill composite resins have higher translucency than conventional composite resins also content of modified filler and organic matrix to ensure adequate curing processes when compared to conventional composite resins. Shorter application times may reduce the risk of trapped air or contamination from moist air.[8] The restorative material should be well adapted within the oral cavity. Environmental influences in the oral cavity such as temperature, acidity or base, and pressure (high stress) may affect the durability of the material. There is fluctuation in temperature in the oral cavity due to consumption of hot and cold food and drink. There have been several studies which suggest that in vitro simulation can be useful for estimating the resilience of dental material and mechanically evaluating the structure changes during clinical use (aging). One of which is thermocycling test in the field of laboratory experimental (laboratory research).[9,10]

Thermocycling tests have been carried out in research since 1952. This conventional system is used to simulate the aging process in vitro from the restorative material through repeated exposure of hot and cold temperature cycles in the water in attempt to resemble thermal changes in the oral cavity.[10] The temperature used for the test is about 5 ^{o}C and 55 ^{o}C according to International Standards Organization (ISO) 11405 (1994). Moresi (2015) stated that thermocycling procedure was carried out with temperatures of 5 and 55 ^{o}C with a dwell time of 30 seconds and a switching time between 5 seconds. A number of in vitro studies of composite resin material after a thermocycling test showed that artificial aging processes may accelerate material degradation by water absorption in a long time and significantly decrease mechanical properties. It is also stated that thermocycling test that using 500-cycle corresponds to the number of cycles expected to occur within about 2 months composite resin in the oral cavity.[11,12]

Mechanical strength is an important factor to be analyzed in the clinical success of a material. One of the mechanical properties of the composite resin is diametral tensile strength that is strength against force which causes the material to strain or lengthen before the material is finally broken. In some cases, brittle restorative materials are weaker in tension than pressure or compression. This property may contribute to the failure of the restorative material therefore affect the strength of the composite resin to withstand the mastication load.[4,10] The diametral tensile strength test is used to determine the brittle material with little or no plastic deformation. This test uses cylindrical specimens submitted to the press load in the diametric plane, which is vertical to the longitudinal axis. [13]

The purpose of the research is to analyze the thermocycling test effect using 1500 (equal with clinically used for 6 month) and 3000 cycles (equal with clinically used for 1 year) to the diametral tensile strength value.

MATERIAL AND METHODS

The research is a true experimental research with post test only with control group design. Twenty four specimen were divided into 3 groups, that were not treated as control, treatment group with thermocycling test of 1500 cycles and treatment group with thermocycling test of 3000 cycles. The specimen were made by using cylindrical specimen molds with diameter of 6 mm and thickness of 3 mm according to ADA specification no. 27 and composite resin that is used is Tetric N-Ceram Bulk Fill Ivoclar Vivadent. The composite resin is applied with depth of 3 mm using plastic filling instrument, then irradiated for 20 seconds. Furthermore, the specimen are removed from the mold and stored in beaker with saline solution and placed in an incubator at 37°C for 24 hours. The specimens for the control group were stored in a humid container, while the treatment group specimens were tested thermocycling at 1500 and 3000 cycles with a temperature of 5°C for 30 seconds and temperature 55°C for 30 seconds. All specimens in the control group and the treatment group were subjected to a diametral tensile strength test using a Universal Testing Machine with crosshead speed of 0.5 mm / min and 250 KgF load. The data result are analyzed by One Way Annova with significance value $p < 0.05$.

RESULT

The data result of the diametral tensile strength value of bulk fill composite type resin can be seen in Table 1.

Table 1. Mean value of diametral tensile strength of bulk fill composite resin with thermocycling test ± Standard Deviation (MPa).

Groups	Mean ± Standard Deviation (MPa)
Control	42.35 ± 4.08[a]
thermocycling 1500 cycle	42.25 ± 2.26[a]
thermocycling 3000 cycle	39.98 ± 1 ,84[a]

*Value with different superscript letters shows significant difference at $p < 0.05$

Based on Table 1, it is known that the mean value of diametral tensile strength of the bulk fill composite resin from highest to lowest are control group (42,35 ± 4,08 MPa), treatment group with thermocycling test of 1500 cycles (42,25 ± 2,26) and in treatment group with thermocycling test of 3000 cycles (39,98 ± 1,84 MPa). One Way Annova result show that all treatment groups were not significantly different (p<0,05).

DISCUSSION

The research used bulk fill composite resin which is brand Tetric N-Ceram bulk fill from Ivoclar Vivadent. The type of composite resin is a nanohibride composite resin that has monomer composition comprising of Bis-GMA, UDMA, and Bis-EMA. [14,15] Diametral tensile strength test may show different values based on differences of filler size, polymer matrix and bond between filler and matrix. The matrix containing Bis-GMA is an aromatic ester of dimethacrylate, comprising of epoxy resin and methyl methacrylate. This makes it rigid with a high viscosity, so the diametral value of tensile strength in this study may be different from other studies. [1] The mean diametral tensile strength value in this study was ranged between 38-46 MPa. This value is still within the limit value of diametral tensile strength of composite resin as a restorative material which is 30-55 MPa. [14,15] Result of the research indicates that statistically there is no significant difference. This is probably influenced by several factors, one of which is the composition of the composite resin Tetric N-Ceram Bulk-fill which has an additional prepolymer filler called isofiller that can reduce shrinkage during process of polymerization. This filler particle has a low elastic modulus (10 GPa) so it is more flexible. [11,12] Another factor that may also affects the result of thermocycling test is the number of cycles used in this study is still less, which the cycle of 1500 cycles equals the duration of the material is in the oral cavity for 6 months and 3000 cycles equals the duration of the restorative material within the oral cavity for 1 year.

Thermocycling test is a laboratory test with a conventional system to simulate in vitro aging process of the restoration material by repeating the cycles of low and high temperature cycles within the waterbath in an attempt to simulate thermal changes in the oral cavity. Repeated temperature changes in the thermocycling test may cause degradation of the bond between the filler and the resin matrix due to the difference of thermal expansion coefficient of the filler and the resin matrix. Thermocycling specimens undergo temperature fluctuations resulting in thermal stress and microfractures in the resin matrix or interface failure between the resin matrix and the filler. In addition, water exposure may cause hydrolytic degradation of the silane coupling agent-filler layer. The organic matrix on a water-absorbing composite resin, causing hygroscopic expansion in the resin matrix thus weakens the interface bond between the resin matrix and the filler.[11,15,16,17,18]

Degradation of composite resin matrix may occurs through several mechanisms. The water diffuses into the composite resin which then it is accumulated on the surface between the resin and the filler material, furthermore it reacts with the silane coupling agent and filler material then release degradation product in the form of residual monomer. This statement is in line with De Munck et al (2005), which state that temperature changes in the thermocycling process can accelerate the hydrolysis process and increase the water absorption process that interferes with the polymerized composite resin bonds. [16,22] The absorbed water may weakens polymer resin bond by way of swelling on the microstructure of composite resin. therefore, the absorbed water will cause permanent damage to the composite resin with the formation of microcraks through repeated absorption process. [6,12]

Medeiros (2015) stated that degradation of composite resin may also occurred through hydrolysis. This complex process occurs after water enters the polymer, water intrusion triggers polymer degradation resulting in the formation of oligomers and monomers. progressive degradation transforms the microstructure of the resin composite through the formation of the cavity ie the oligomers and the residual monomers which are the degradation products will later be released. This process can be responsible for decreasing mechanical properties even it is not statistically different in the research. [21] Yilmaz and Sadeler (2016) and Dos Santos et al (2015) stated that the relationship between thermocycling and changes in the physical properties of composite resins is difficult to be predicted because of the varying number of cycles, difference of minimum and maximum temperatures, dwell time and transfer time, generally the temperature often used in the literature is 5 ° C-55 ° C with a dwell time of 30 seconds. . [16,22] This result is in line with a study conducted by Oliviera (2010) which state that composite resin stored in water and had thermocycling tests had no significant effect on changes in the physical properties of composite resin.[16,22,23] Based on the research, it can be concluded that thermocycling test with 1500 cycles and 3000 cycles to composite resin not altered the diametral tensile strength value.

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