Effect of thermocycling on the flexural strength of two different composite filling materials: An *in vitro* study

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J. Adv. Pharm. Technol. Res.

Abstract

Flexural strength is the bend strength or stress which causes failure in bending of the material. Composite is the widely used restorative material in the era of esthetic dentistry as it provides better esthetic and mechanical support for both posterior and anterior teeth. The term "thermocycling" refers to the process of changing temperatures in the mouth. Thus, the aim of the study was to determine the effect of thermocycling on flexural strength in two different composite filling materials. Twelve samples of packable type composite filling material, among which four samples prepared were from Restofill I (Group 1) and four were prepared from Ivoclar Vivadent (Group 2) for the study. Bar-shaped composite resin specimens were prepared with dimensions of 2 mm × 2 mm × 25 mm. Then, the eight samples were subjected to a thermocycling process and four left as control. This was followed by the determination of maximum force by a universal testing machine, and then, the collected data were used to determine flexural strength using the formula. The determining flexural strength was analyzed using SPSS version 23.0 by Independent sample *t*-test. The mean flexural strength of thermocycled Restofill composite filling material is 6.73, whereas the nonthermocycled Restofill sample showed 5.58 and the mean flexural strength of thermocycled Ivoclar Vivadent composite filling material was 5.08. The difference was not statistically significant with $P = 0.978 > 0.05$. The current study concludes that the flexural strength of the Restofill composite (Group 1) was higher than the Ivoclar composite (Group 2). Hence, thermocycling affects the flexural strength of composite resin.

Key words: Composite material, dental materials, flexural strength, innovative measurement, thermocycler, universal testing machine

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Submitted: 27-Apr-2022 **Accepted:** 16-Jun-2022
Published: 30-Nov-2022

Access this article online
Quick Response Code:
Website: www.japtr.org
DOI: 10.4103/japtr.japtr_252_22

INTRODUCTION

Flexural strength is the bend strength or stress which causes failure in bending of the material. The stress will be highest at the edge (concave surface), and lowest at the convex surface, i.e., when bending a material, the extreme fibers will be under more stress than the other fibers.[1] Composite is the widely used restorative material in the era of esthetic dentistry as it provides better esthetic and

How to cite this article: Taskeen LT, Ganesh SB, Jayalakshmi S. Effect of thermocycling on the flexural strength of two different composite filling materials: An *in vitro* study. J Adv Pharm Technol Res 2022;13:S121-4.

mechanical support for both posterior and anterior teeth.[2] Although it is used widely, it has to be prepared in such a way that it even shows low fracture strength, which can promote the material utility even in patients with parafunctional habits such as bruxism.[3] Because composite resins, particularly cavities under stress, are exposed to tension and compression forces, flexural strength is critical for composite resin makers.[4]

Dental materials and teeth are exposed to a temperature in the laboratory by a process called thermocycling that produces consequences due to different coefficients of thermal expansion between the structure and the composite or any other filling material.[5] Thermal aging is determined by the thermocycling process as it signifies the fluctuating temperatures in the oral cavity with many cycles, which can affect the bond strength between materials and tooth structure.[6] Flexure hence thermocycling is done to determine its effect on the flexural strength of the different composites.[7]

According to recent study done by Morresi *et al*., 2015 reported that on thermocycling, there is a reduction of flexural strength and flow of composite in sixty samples with a dimension of 2 mm × 2 mm × 25 mm and similarly, another study done by D'Amario *et al*., 2013 had reported that lower flexural strength in composite, whereas Morresi AL *et al*., 2015 had declared that flexural strength and microhardness vary between materials irrespective of thermocycling.[8,9]

In the research field, though there is much research done to evaluate the flexural strength of different composite materials, there is no study done that compares the flexural strength of Restofill and Ivoclar. Hence, the current study fulfills the lacunae by determining the effect of thermocycling on the flexural strength of Restofill and Ivoclar material. Our research and knowledge have resulted in high-quality publications from our team.[10-24] Thus, the aim of the study was to determine the effect of thermocycling on flexural strength in two different composite materials.

MATERIALS AND METHODS

Sample preparation for the *in vitro* study

The investigation was conducted at Saveetha Dental College and Hospital's White Lab Material Research Centre. For the *in vitro* study, twelve samples of packable type composite filling material were prepared, four from Restofill (Group 1) and four from Ivoclar Vivadent (Group 2). Each group produced bar-shaped specimens with a dimension of 2 mm × 2 mm × 25 mm using a mold of the prescribed size, and each increment was cured for 30 s each with the help of a light-emitting diodes curing light, polished using a micromotor with the Composite polishing kit, and the final dimensions were checked with a digital caliper.

Determination of thermal aging of composite filling materials

The thermocycling process was carried out for four samples from each group and two from each group taken as control which were kept in distilled water (Group 1 and Group 2). Each sample were packed in a gauze piece and subjected to a thermocycling process using TC 4 SD Mechatronik, an integrated thermocycler which was set with two different temperatures (cold −4°C and hot −60°C) for 1000 cycles which equates 6 months with a dwell time of 30 s and drain time of 10 s each.

Determination of flexural strength of composite filling materials

The thermocycled and nonthermocycled samples were subjected to an INSTRON E3000 UTM (ElectroPuls) three-point bend test with a span length of 16 mm and a cross head speed of 1 mm/min to measure the maximum force and maximum flexural displacement [Figure 1].

The flexural strength is calculated using the following formula:

$S = 3FL/2bd^2$

where S = flexural strength or modulus of fracture

F = Load at the fracture point which samples failed between loaded bearing edges

L = Length of the support span (16 mm)

b = Width of the test samples (2 mm)

d = Thickness of the test samples (2 mm)

The flexural strength was calculated using the data obtained and summarized in the Instron Bluehill program.

Figure 1: The image depicts the determination of flexural strength using the INSTRON E3000 machine

Independent sample test analysis in SPSS version 23.0 (IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.) was used to determine the differences between the groups.

RESULTS

The mean of flexural strength of thermocycled Restofill composite filling material is 5.44 and the mean of flexural strength of thermocycled Ivoclar Vivadent composite filling material was 5.08 and which is shown in Table 1 and the Restofill and Ivoclar had similar flexural strength which was not statistically significant (0.978 > 0.05) as it is in Table 2.

DISCUSSION

Thermocycling is the common process used for determining the degradation of various dental materials over the years. Hence, the thermocycling process was done to determine the difference of flexural strength in Restofill and Ivoclar Vivadent which showed an increase in flexural strength of Ivoclar (5.08) after thermocycling, whereas Restofill (5.58) reduced after thermocycling as its control value was higher than. Similarly, the composite after immersing in water and thermocycling showed ten times higher value than the control in the study done by Göhring *et al*. in 2015.[25]

Benalcázar Jalkh *et al*. in 2019 reported that the biaxial flexural strength was tested for different composites such as Ceram Bulk Fill and Filtek Bulk Fill after the thermocycling process and found that the flexural strength was higher after thermocycling than the control,[26] which is similar to the current study results as flexural strength is the designation of the bend strength of the dental material used in the study which has to be higher to make the composite material valued to usage. Hence, as per the results for Ivoclar Vivadent, it has increased after thermocycling compared to Restofill samples as shown in Table 1.

Table 1: The mean values of flexural strength of Restofill and Ivoclar Vivadent samples

Samples	Restofill (Group 1)	Ivoclar Vivadent (Group 2)
Sample 1 (thermocycled)	5.22	5.15
Sample 2 (thermocycled)	4.94	4.46
Sample 3 (thermocycled)	5.79	4.98
Sample 4 (thermocycled)	5.84	5.74

Table 2: The flexural strength mean, standard deviation, and significance of Restofill and Ivoclar

Groups	Number of samples	Mean±SD	Significance
Restofill	4	5.4475±0.43995	0.978
Ivoclar	4	5.0825±0.52753	

SD: Standard deviation

Telio CAD and ESPE™ Lava™ Ultimate Restorative and CERASMART and lithium disilicate ceramic all materials were been subjected to thermocycling and their flexural strength was determined which showed mean flexural strength of 313 ± 56 MPa to 94 ± 4 which has been reduced compared to the value before thermocycling which seems to be controversial to the present study.[27]

GC Gradia (GRD), VITA VM LC, and Sinfony was been used to determine the physical property of the three different composite material done by Stawarczyk *et al*. in 2011 and concluded that there was an increase in post flexural strength value than the control value for all the samples used[28] which goes hand in hand with results of the current study which was performed for the two different composite filling materials with different material.

The limitations of the study can be the error during the preparation of the samples with different dimensions or there may be instrument error or manual error while data collection, the entry of data can be mistaken and the less sample size can all affect the results. Hence, more criteria have to be included and many cycles have to be done to determine the proper thermal aging of the material and to generalize the results of the current study. The determination of flexural strength will aid the dentist in selecting more reinforced materials to provide patients with better treatment and improve the treatment's prognosis.

CONCLUSION

The current study concludes that the flexural strength of the Restofill composite (Group 1) was higher than the Ivoclar composite (Group 2). Hence, thermocycling affects the flexural strength of composite resin.

Acknowledgment

The first author is grateful to the White Lab for helping to finish the fieldwork in the stipulated time.

Financial support and sponsorship

The present study was supported by the following agencies:

- Saveetha Dental College, SIMATS, Saveetha University, Chennai
- Tancreative Company.

Conflicts of interest

There are no conflicts of interest.

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