SCIENTIFIC DENTAL JOURNAL

FACULTY OF DENTISTRY, TRISAKTI UNIVERSITY

P-ISSN : 25806548 E-ISSN : 2541321X Subject Area : Health, Science, Education

0
Impact

258
Google Citations

Sinta 2
Current Acreditation

Google Scholar Garuda Website Editor URL

History Accreditation

2017 2018 2019 2020 2021 2022 2023

Garuda Google Scholar

The Effects of Different Bracket Types on Orthodontic Treatment Evaluated with the Objective Grading System
Faculty of Dentistry, Trisakti University Scientific Dental Journal Vol. 3 No. 1 (2019): JANUARY 9-16
2019 DOI: 10.26912/sdj.v3i1.3634 Accred : Sinta 2

Bimaxillary Orthognathic Surgery in Skeletal Class III Malocclusion
Faculty of Dentistry, Trisakti University Scientific Dental Journal Vol. 3 No. 1 (2019): JANUARY 23-29
2019 DOI: 10.26912/sdj.v3i1.3662 Accred : Sinta 2

Lower Facial Height and Soft Tissue Changes in Bimaxillary Protrusion Cases
Faculty of Dentistry, Trisakti University Scientific Dental Journal Vol. 3 No. 1 (2019): JANUARY 1-7
2019 DOI: 10.26912/sdj.v3i1.3633 Accred : Sinta 2

Compatibility of Types III/IV Gypsum with Addition Silicone Impression Material
Faculty of Dentistry, Trisakti University Scientific Dental Journal Vol. 3 No. 1 (2019): JANUARY 17-22
2019 DOI: 10.26912/sdj.v3i1.3664 Accred : Sinta 2

Oral Opportunistic Infections in Patient with HIV Wasting Syndrome
Faculty of Dentistry, Trisakti University Scientific Dental Journal Vol. 3 No. 1 (2019): JANUARY 31-39
2019 DOI: 10.26912/sdj.v3i1.3608 Accred : Sinta 2

[Analyzing the Width of the Maxillary Sinus from Private Practice in Bogor, Indonesia]
Faculty of Dentistry, Trisakti University Scientific Dental Journal Vol. 2 No. 2 (2018): May 59-66
2018 DOI: 10.26912/sdj.v2i2.2504 Accred : Sinta 2

The Efficacy of Fish Scales as Bone Graft Alternative Materials
Faculty of Dentistry, Trisakti University Scientific Dental Journal Vol. 2 No. 1 (2018): January 9-17
2018 DOI: 10.26912/sdj.v2i1.1954 Accred : Sinta 2

Chewing Gum, Acetaminophen, and Green Tea Effect in Reducing Pain After Orthodontic Appliance Placement
Faculty of Dentistry, Trisakti University Scientific Dental Journal Vol. 2 No. 2 (2018): May 51-57
2018 DOI: 10.26912/sdj.v2i2.2530 Accred : Sinta 2

Comparing the Effectivities of Chitosan Citrate and Chitosan Acetate in Eradicating Enterococcus faecalis Biofilm
Faculty of Dentistry, Trisakti University Scientific Dental Journal Vol. 2 No. 1 (2018): January 1-7
2018 DOI: 10.26912/sdj.v2i1.2290 Accred : Sinta 2

Enzymatic Activity of Bromelain Isolated Pineapple (Ananas comosus) Hump and Its Antibacterial Effect on Enterococcus faecalis
Faculty of Dentistry, Trisakti University Scientific Dental Journal Vol. 2 No. 2 (2018): May 39-50
2018 DOI: 10.26912/sdj.v2i2.2540 Accred : Sinta 2

View more ...

ISSN (Print) : 2580–6548
ISSN (Online): 2541–321X

Volume 4 • Issue 2 • Mei-August 2020

SCIENTIFIC DENTAL JOURNAL

Official Journal of Faculty of Dentistry, Trisakti University, Jakarta, Indonesia

www.scidentj.com

Wolters Kluwer

Medknow

Scientific Dental Journal

Volume 4 | Issue 2 | May - August 2020

CONTENTS

Original Article

The Effect of Repeated Preheating on Diametral Tensile Strength of Composite Resin with Different Fillers

Ellen Winarta, Tien Suwartini[1], Anastasia Elsa Prahasti[1], Rosalina Tjandrawinata[2]

Conservative Dentistry Post Graduate Program, Faculty of Dentistry, Trisakti University, Departments of [1]Conservative Dentistry, [2]Dental Biomaterial, Faculty of Dentistry, Trisakti University, West Jakarta, Java, Indonesia

Abstract

Background: The development of adhesive systems has made the removal of carious lesion a minimally invasive procedure. Composite resin is the material of choice today, but the filler composition of the resin varies. Packable composite resin has good mechanical properties, but its high viscosity makes it hard to manipulate. Several methods, such as preheating, are used to decrease this viscosity. A syringe of composite resin might be preheated several times, but the effect of repeated preheating is unknown. **Objectives:** The purpose of this research was to analyze the effect of repeated preheating on the mechanical properties of a composite resin with different fillers. **Method:** Microhybrid, nanohybrid, and nanofill composite resins were preheated (ten times, twenty times, and control), molded into cylinder molds 6 mm in diameter and 3 mm in height, flattened with a celluloid strip, and polymerized with an light-emitting diode light-curing unit for 40 s. A total of 180 specimens were tested. The specimens were divided into two groups: Group 1 was immediately tested using a universal testing machine. Group 2 was soaked in 37°C artificial saliva for 24 h before testing. Each specimen was tested using the universal testing machine with the pressure side with a 1 mm/s crosshead speed. **Result:** Nanohybrid composite resin had the most stable diametral tensile strength after repeated preheating, whereas nanofill composite had the weakest strength. The increase and decrease in the diametral tensile strength in each group were not statistically significant. **Conclusion:** Repeated preheating does not significantly affect the diametral tensile strength of composite resin.

Keywords: *Composite resin, diametral tensile strength, repeated preheating*

Received : 01-10-19
Revised : 18-12-19
Accepted : 06-05-20
Published Online: 08-06-20

Background

The development of adhesive systems has made composite resin the material of choice today.[1,2] Cavity preparation has been minimized,[3] but a small cavity is difficult to restore with condensable composites.[4-6] During mastication, the restoration is placed under pressure;[7] therefore, composite restorations require good mechanical properties.[8] A significant correlation is found between the surface of the composite restoration and its diametral tensile strength.[9] Composite resin fillers have been studied for the recommended use in the posterior teeth.[10,11]

Recently, a preheating device has been marketed.[12] Soliman concluded that heating a composite resin increased its micro strength.[13] Uctasli revealed that heated composite resin had a better adaptation to the cavity wall.[14] Nada and El-Mowafy indicated that heating composite resins increased their compression strength.[15] One syringe of composite resin can be used several times, which means that the heating process may also be repeated many times.[16,17] The aim of this study was to analyze whether reheating of composite resins has an impact on the diametral tensile strength of composite resins.

Materials and Methods

The samples in this study were 180 composite resin specimens with cylindrical shape 6 mm in diameter

Access this article online

Quick Response Code:	
	Website: www.scidentj.com
	DOI: 10.4103/SDJ.SDJ_35_19

Address for correspondence: Dr. Tien Suwartini, Trisakti University, West Jakarta, Java, Indonesia.
E-mail: tiensuwartini@hotmail.com

How to cite this article: Winarta E, Suwartini T, Prahasti AE, Tjandrawinata R. The effect of repeated preheating on diametral tensile strength of composite resin with different fillers. Sci Dent J 2020;4:44-8.

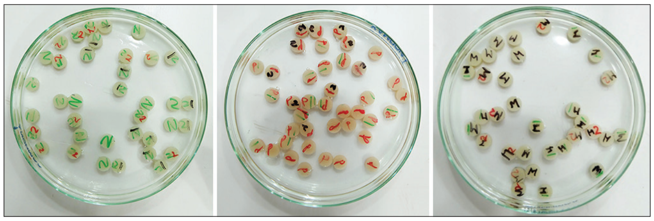

Figure 1: Specimens were soaked in artificial saliva

and 3 mm in height. The samples were fabricated from microhybrid (Z250, 3M, USA), nanofill (Palfique LX 5, Tokuyama, Japan), and nanohybrid (Ena Hri, Micerium, Italy) composite resins. Each resin was heated ten times or twenty times or not heated as a control, and the diametral tensile strength of the specimens (in groups of ten) was analyzed either immediately or after 24 h.

The composite resin heating process was carried out by inserting the composite resin syringe into a Micerium heater for 10 min at 39°C, then the material was removed with plastic filling (Hu Friedy, USA) from the syringe, and put into a 6 mm diameter and 3 mm high mold. The top surface of the composite resin was flattened using a celluloid strip (Mylar, Dentamerica), and then, the resin was polymerized using a light-curing unit (Ledex, Taiwan) at a wavelength of 470 nm for 40 s. The tip of light-curing unit was set to touch the celluloid strip.[18,19] Specimens in the Group 1 were immediately tested for their diametral tensile strength using a universal testing machine[20] (Shimadzu, Japan), whereas Group 2 [Figure 1] was immersed in artificial saliva at 37°C for 24 h before diametral tensile strength testing.[9] Diametral tensile strength was tested with a universal testing machine at PT INTEC, Karawang.

Statistical analysis

The normality of the data was tested using the Shapiro–Wilk test, which confirmed normally distributed data ($P > 0.05$). Data analyses were performed using the two-way ANOVA test using SPPS version 20 (IBM, N.Y., USA).

Results

The result of the diametral tensile strength of the three materials tested is varied [Table 1]. The statistical analysis result is shown in Table 2 which confirmed a significant difference in the diametral tensile strength among the three resin materials ($P = 0.000$).

Discussion

Research on the mechanical properties of heated composite resin is important for understanding the effects of heat on the ability of these materials to withstand mastication loads.[13,15] Increasing the temperature of the composite resin escalates the mobility of free radicals and monomers, thereby increasing the monomer conversion. This, in turn, improves the degree of polymerization, as well as the polymer crosslinking, mechanical properties, and physical properties.[14,15] High surface hardness and increased depth of polymerization are other advantages gained by heating composite resins.

The diametral tensile strength is an important factor to examine because it relates to the resistance to lateral forces that occur during mastication.[21] In this study, composite resins were heated according to the recommendations of the heating device, which is 39°C. The composite resin was repeatedly heated up to twenty times because D'Amario *et al.*'s research has indicated that a single composite resin syringe can be used to fill up to twenty cavities, especially when using the multishade layering technique.[17]

Table 1: Descriptive data of the mean and standard deviations of the diametral tensile strength of different composite resins based on time and treatment

Material	Time	Preheated	Mean	SD	*n*
Nanohybrid	24 h	Control	44.50	11.20	10
		10×	42.00	11.47	10
		20×	44.90	8.81	10
	Immediate	Control	30.70	5.63	10
		10×	35.50	5.31	10
		20×	41.10	9.84	10
Nanofill	24 h	Control	34.60	7.48	10
		10×	29.30	3.05	10
		20×	27.20	4.23	10
	Immediate	Control	34.80	2.82	10
		10×	32.40	3.59	10
		20×	35.60	2.27	10
Microhybrid	24 h	Control	46.80	4.54	10
		10×	40.30	5.25	10
		20×	40.40	8.78	10
	Immediate	Control	42.50	7.42	10
		10×	43.60	4.50	10
		20×	46.50	8.46	10

SD: Standard deviation

Table 2: Two-way ANOVA of effects of material, time, and preheating repetitions on diametral tensile strength of the composite resins

	P
Material	<0.01*
Time	0.436
Preheating repetitions	0.206
Material and time	<0.01*
Material and preheating repetitions	0.078
Time and preheating repetitions	0.001*
Material, time, and preheating repetitions	0.949

*Significance: $P<0.05$

The composite resins in this study are provided in syringes. The temperature of the material is maintained stable by placing heaters near the composite resin molds, with the aim of simplifying and speeding up the processing time while preventing a decrease in temperature during material manipulation. This was suggested by Daronch *et al*., as clinicians must work fast to ensure that only a slight decrease in temperature occurs.[22] The results of previous studies show that the temperature of the composite resin drops rapidly when the syringe is removed from the heater, and the composite resin is taken to the tooth surface.[13]

The microhybrid composite resin in this study showed an increase in diametral tensile strength in the immediately tested group. Nada and El-Mowafy study of microhybrid composite resins showed an increase in the surface hardness of the heated composite resin.[15] The degree of conversion is the percentage of carbon–carbon double bonds that have been converted into a single bond to form a polymeric resin. The higher the degree of conversion, the better the strength, wear resistance, and other important properties related to resin performance.[23] Meanwhile the shrinkage on polymerization related to the cavity configuration.[24]

The nanofill composite resin used in this study had the lowest diametral tensile strength when compared to the nanohybrid and microhybrid composite resins. This is due to the differences in the morphology of the composite resin filler. The nanofill composite resin tested in this study is a composite resin with a filler morphology in the form of prepolymerized fillers. Research by Kim *et al*. found that the amount of filler in composite resins was influenced by the filler morphology. Composite resins that contain prepolymerized filler particles have the lowest amount of filler. This type of composite resin also has the lowest flexural strength compared to composite resin with an irregular filler type or a mixture of prepolymerized and irregular forms.[25]

The microhybrid and nanohybrid composite resins tested in this study have higher diametral tensile strength than nanofill composite resins because hybrid composite resins have smaller filler particles that can enter between large fillers to filling the empty spaces between them, thereby providing better strength. By contrast, the nanofill composite resin has a filler with a rounded shape, which leaves a space among fillers, therefore decreased the strength when compared with the hybrid composite resins.

In this study, an increase and decrease were observed in the tensile strength of diametral nanohybrid, nanofill, and microhybrid composite resin composites after heating ten and twenty times when compared to controls, but the changes were not statistically significant. Research by D'Amario on nanohybrid composite resins also revealed that composite resins retain their same mechanical characteristics after 1, 10, 20, 30, and 40 times heating cycles at 39°C. The mechanical characteristics of the composite resin were not significantly different from those of the unheated composite resin.

The results in this study indicate that the significant difference observed in the diametral tensile strength between the three heated composite resins is likely due to the different filler and monomer contents. Therefore, different materials are likely to have different reactions when heated. In addition, the ability of each material to be heated also plays an important role in the compression strength of the material. Only the nanohybrid composite resins used in this study can be heated, according to their product descriptions.

This study conducted an immediate and 24 h diametral tensile strength tests to determine whether time has an influence on the diametral tensile strength. The results indicated that there are no effects of time on the diametral tensile strength. The choice of treatment time "immediately" after polymerization is important because the operator expects that the restoration will be sufficiently polymerized to endure mastication forces immediately after polymerization. If a time interval is needed for the restoration to accept this force, additional information should be listed in the manufacturer's instructions. However, manual instructions on this subject are not usually provided, but a diametral tensile strength test can immediately be carried out after polymerization.[27]

The 24 h time was chosen because a postcure polymerization occurs due to the photoactivation properties of the composite resin. After polymerization, free radicals trapped in the matrix can continue to react to slowly make bonds over time. Postcure reactions can continue as long as free radicals and reactants (for example, pendant methacrylate groups and free monomers) are still present. In general, postcure polymerization occurs during the first 24 h after polymerization. After 24 h, the amount of free radicals will decrease, and any subsequent polymerization will proceed very slowly.[28-30]

A literature study reveals that no adverse effects occur regarding the mechanical properties of composite resins due to heating procedures.[31] Research by Osternack *et al*. on microhybrid resins concluded that composite resin hardness was not affected by heating or cooling.[32] However, the majority of previous studies did not carry out repeated heating cycles. Daronch *et al*. reported that prolonged heating or ten0 repetitions of heating did not affect the degree of conversion when compared to composite resins maintained at room temperature.[18] A study by D'Amario *et al*. on nanohybrid composite resins revealed that repeated cycles of heating to 39°C did not affect the mechanical properties of composite resins. Heating to 39°C is considered sufficient to increase flowability and better adaptation to composite resins.[17]

Other ways to increase the viscosity of composite resins have been developed, including reducing the viscosity of monomers and using sonic vibrations. The viscosity of monomers can be reduced by combining bisphenol A-glycidyl methacrylate with triethylene glycol dimethacrylate. Sonic vibrations are thought to reduce the viscosity of the resin by increasing the flowability of composite resins.[4]

Besides the temperature of 39°C used in this study, other temperatures can be used for heating composite resin. The Ena Heat heater (Micerium S.p.A, Avegno, GT, Italy) has a heating temperature of 55°C that, according to the manufacturer's instructions, will produce composite resin with high flowability for use in cementation. In addition to the Ena Heat model, another composite resin heater on the market is the Calset (AdDent Inc., Danbury, CT, USA). This tool can heat the composite resin at 54°C and 68°C.

The marginal adaptation of composite resin is significantly better in axial walls when the composite resin is preheated.[6] El-Deeb *et al*. examined the effect of heating composite resin at 54°C and 68°C on the increase in intrapulp temperature and found that heating of composite resin increased intrapulp temperature without endangering the vitality of the pulp.[33]

Apart from the effects of heating on the mechanical properties of composite resins, a debate still exists over the shrinkage that occurs in heated composite resins. Deb *et al*. and Didron *et al*. indicated shrinkage in heated composite resin, but Lohbauer said that any shrinkage that occurred was not significant.[11,12,26]

Conclusion

Repeated heating has different effects on the diametral tensile strength of composite resins with different filler types. The nanohybrid composite resin in this study had the most stable diametral tensile strength after heating compared to nanofill and microhybrid types. The nanofill composite resin in this study had the lowest diametral tensile test compared to the other composite resins.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Amerongen JP, Amerongen WE, Watson TF, Opdam NJ, Roeters FJ, Bittermann D, *et al*. Restoring the tooth: The seal is the deal. In: Fejerskov O, Kidd E, editors. Dental Caries: The Disease and its Clinical Management. 2nd ed. Copenhagen: Blackwell Muksgaard; 2008. p. 393.
2. McCabe JF, Walls AW. Resin based filling material. In: McCabe JF, Walls AW, editors. Applied Dental Materials. 9th ed. Copenhagen: Blackwell Munksgaard; 2007. p. 196-202.
3. Frencken JE, Peters MC, Manton DJ, Leal SC, Gordan VV, Eden E. Minimal intervention dentistry for managing dental caries – A review: Report of a FDI task group. Int Dent J 2012;62:223-43.
4. Baroudi K, Rodrigues JC. Flowable resin composites: A systematic review and clinical considerations. J Clin Diagn Res 2015;9:ZE18-24.
5. Wagner WC, Aksu MN, Neme AM, Linger JB, Pink FE, Walker S. Effect of pre-heating resin composite on restoration microleakage. Oper Dent 2008;33:72-8.
6. Froes-Salgado N, Silva LM, Kawano Y, Francci C, Reis A, Loguercio A. Composite preheating: Effects on marginal adaptation, degree of conversion and mechanical properties. Dent Mater 2010;26:908-14.
7. Wang L, D'Alpino PH, Lopes LG, Pereira JC. Mechanical properties of dental restorative materials: Relative contribution of laboratory test. J Appl Oral Sci 2003;11:162-7.
8. Gömeç Y, Dörter C, Dabanoglu A, Koray F. Effect of resin-based material combination on the compressive and the flexural strength. J Oral Rehabil 2005;32:122-7.
9. Thomaidis S, Kakaboura A, Mueller WD, Zinelis S. Mechanical properties of contemporary composite resins and their interrelations. Dent Mater 2013;29:e132-41.
10. Bartlett D, Sundaram G. An up to 3-year randomized clinical study comparing indirect and direct resin composites used to restore worn posterior teeth. Int J Prosthodont 2006;19:613-7.
11. Lohbauer U, Zinelis S, Rahiotis C, Petschelt A, Eliades G. The effect of resin composite pre-heating on monomer conversion and polymerization shrinkage. Dent Mater 2009;25:514-9.
12. Deb S, Di Silvio L, Mackler HE, Millar BJ. Pre-warming of dental composites. Dent Mater 2011;27:e51-9.
13. Soliman EM, Elgayar IL, Kamar AA. Effect of preheating in microleakage and microhardness of composite resin (an *in vitro* study). Alex Dent J 2016;41:4-11.
14. Uctasli MB, Arisu HD, Lasilla LV, Valittu PK. Effect of preheating on the mechanical properties of resin composites. Eur J Dent 2008;2:263-8.
15. Nada K, El-Mowafy O. Effect of Precuring Warming on Mechanical Properties of Restorative Composites. Int J Dent 2011;2011:1-5.
16. D'Amario M, Pacioni S, Capogreco M, Gatto R, Baldi M. Effect of repeated preheating cycles on flexural strength of resin composites. Oper Dent 2013;38:33-8.
17. D'Amario M, de Angelis F, Vadini M, Marchili N, Mummolo S, D'Arcangelo C. Influence of a repeated preheating procedure on mechanical properties of three resin composites. Oper Dent 2015;40:181-9.

18. Daronch M, Rueggeberg FA, Moss L, de Goes MF. Clinically relevant issues related to preheating composites. J Esthet Restor Dent 2006;18:340-50.
19. Rode KM, Kawano Y, Turbino ML. Evaluation of curing light distance on resin composite microhardness and polymerization. Oper Dent 2007;32:571-8.
20. Bresciani E, Barata Tde J, Fagundes TC, Adachi A, Terrin MM, Navarro MF. Compressive and diametral tensile strength of glass ionomer cements. J Appl Oral Sci 2004;12:344-8.
21. Aguiar FH, Braceiro AT, Ambrosano GM, Lovadino JR. Hardness and diametral tensile strength of a hybrid composite resin polymerized with different modes and immersed in ethanol or distilled water media. Dent Mater 2005;21:1093-203.
22. Daronch M, Rueggeberg FA, Goes MF, Giucidi R. Polymerization kinetics of preheated composite. J Dent Res 2006;85:38-43.
23. Anusavice KJ, Shen C, Rawls HR. Philips' Science of Dental Material. 12th ed. St. Louis (MO): Elsevier; 2013.
24. Oskoee PA, Azar FP, Navimipour EJ, Chaharom ME, Alavi NF, Salari A. The effect of repeated preheating of dimethacrylate and silorane-based composite resins on marginal gap of class V restorations. J Dent Res Dent Clin Dent Prospects 2017;11:36-42.
25. Kim KH, Ong JL, Okuno O. The effect of filler loading and morphology on the mechanical properties of contemporary composites. J Prosthet Dent 2002;87:642-9.
26. Didron PP, Ellakwa A, Swain MV. Effect of preheat temperatures on mechanical properties and polymerization contraction stress of dental composite. Mater Sci App 2013;4:374-85.
27. Schattenberg A, Lichtenberg D, Stender E, Willershausen B, Ernst CP. Minimal exposure time of different LED-curing devices. Dent Mater 2008;24:1043-9.
28. Ayub KV, Santos GC Jr., Rizkalla AS, Bohay R, Pegoraro LF, Rubo JH, *et al*. Effect of preheating on microhardness and viscosity of 4 resin composites. J Can Dent Assoc 2014;80:e12.
29. Par M, Gamulin O, Marovic D, Klaric E, Tarle Z. Effect of temperature on post-cure polymerization of bulk-fill composites. J Dent 2014;42:1255-60.
30. Alshali RZ, Salim NA, Satterthwaite JD, Silikas N. Post-irradiation hardness development, chemical softening, and thermal stability of bulk-fill and conventional resin-composites. J Dent 2015;43:209-18.
31. Schneider LF, Consani S, Ogliari F, Correr AB, Sobrinho LC, Sinhoreti MA. Effect of time and polymerization cycle on the degree of conversion of a resin composite. Oper Dent 2006;31:489-95.
32. Osternack FH, Caldas DB, Almeida JB, Souza EM, Mazur RF. Effects of preheating and precooling on the hardness and shrinkage of a composite resin cured with QTH and LED. Oper Dent 2013;38:E1-8.
33. El-Deeb HA, Abd El-Aziz S, Mobarak EH. Effect of preheating of low shrinking resin composite on intrapulpal temperature and microtensile bond strength to dentin. J Adv Res 2015;6:471-8.

The Effect of Repeated Preheating on Diametral Tensile Strength of Composite Resin with Different Fillers

by Tien Suwartini FKG

Submission date: 02-Sep-2024 02:26PM (UTC+0700)
Submission ID: 2380782464
File name: KARYA_TULIS_ILMIAH_SDJ.pdf (652.79K)
Word count: 3739
Character count: 19750

Original Article

The Effect of Repeated Preheating on Diametral Tensile Strength of Composite Resin with Different Fillers

Ellen Winarta, Tien Suwartini[1], Anastasia Elsa Prahasti[1], Rosalina Tjandrawinata[2]

Conservative Dentistry Post Graduate Program, Faculty of Dentistry, Trisakti University, Departments of [1]Conservative Dentistry, [2]Dental Biomaterial, Faculty of Dentistry, Trisakti University, West Jakarta, Java, Indonesia

Received : 01-10-19
Revised : 18-12-19
Accepted : 06-05-20
Published Online: 08-06-20

ABSTRACT

Background: The development of adhesive systems has made the removal of carious lesion a minimally invasive procedure. Composite resin is the material of choice today, but the filler composition of the resin varies. Packable composite resin has good mechanical properties, but its high viscosity makes it hard to manipulate. Several methods, such as preheating, are used to decrease this viscosity. A syringe of composite resin might be preheated several times, but the effect of repeated preheating is unknown. **Objectives:** The purpose of this research was to analyze the effect of repeated preheating on the mechanical properties of a composite resin with different fillers. **Method:** Microhybrid, nanohybrid, and nanofill composite resins were preheated (ten times, twenty times, and control), molded into cylinder molds 6 mm in diameter and 3 mm in height, flattened with a celluloid strip, and polymerized with an light-emitting diode light-curing unit for 40 s. A total of 180 specimens were tested. The specimens were divided into two groups: Group 1 was immediately tested using a universal testing machine. Group 2 was soaked in 37°C artificial saliva for 24 h before testing. Each specimen was tested using the universal testing machine with the pressure side with a 1 mm/s crosshead speed. **Result:** Nanohybrid composite resin had the most stable diametral tensile strength after repeated preheating, whereas nanofill composite had the weakest strength. The increase and decrease in the diametral tensile strength in each group were not statistically significant. **Conclusion:** Repeated preheating does not significantly affect the diametral tensile strength of composite resin.

KEYWORDS: *Composite resin, diametral tensile strength, repeated preheating*

BACKGROUND

The development of adhesive systems has made composite resin the material of choice today.[1,2] Cavity preparation has been minimized,[3] but a small cavity is difficult to restore with condensable composites.[4-6] During mastication, the restoration is placed under pressure;[7] therefore, composite restorations require good mechanical properties.[8] A significant correlation is found between the surface of the composite restoration and its diametral tensile strength.[9] Composite resin fillers have been studied for the recommended use in the posterior teeth.[10,11]

Recently, a preheating device has been marketed.[12] Soliman concluded that heating a composite resin increased its micro strength.[13] Uctasli revealed that heated composite resin had a better adaptation to the cavity wall.[14] Nada and El-Mowafy indicated that heating composite resins increased their compression strength.[15] One syringe of composite resin can be used several times, which means that the heating process may also be repeated many times.[16,17] The aim of this study was to analyze whether reheating of composite resins has an impact on the diametral tensile strength of composite resins.

MATERIALS AND METHODS

The samples in this study were 180 composite resin specimens with cylindrical shape 6 mm in diameter

Address for correspondence: Dr. Tien Suwartini, Trisakti University, West Jakarta, Java, Indonesia. E-mail: tiensuwartini@hotmail.com

Access this article online

Quick Response Code:

Website: www.scidentj.com

DOI: 10.4103/SDJ.SDJ_35_19

How to cite this article: Winarta E, Suwartini T, Prahasti AE, Tjandrawinata R. The effect of repeated preheating on diametral tensile strength of composite resin with different fillers. Sci Dent J 2020;4:44-8.

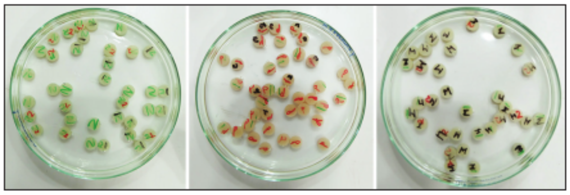

Figure 1: Specimens were soaked in artificial saliva

and 3 mm in height. The samples were fabricated from microhybrid (Z250, 3M, USA), nanofill (Palfique LX 5, Tokuyama, Japan), and nanohybrid (Ena Hri, Micerium, Italy) composite resins. Each resin was heated ten times or twenty times or not heated as a control, and the diametral tensile strength of the specimens (in groups of ten) was analyzed either immediately or after 24 h.

The composite resin heating process was carried out by inserting the composite resin syringe into a Micerium heater for 10 min at 39°C, then the material was removed with plastic filling (Hu Friedy, USA) from the syringe, and put into a 6 mm diameter and 3 mm high mold. The top surface of the composite resin was flattened using a celluloid strip (Mylar, Dentamerica), and then, the resin was polymerized using a light-curing unit (Ledex, Taiwan) at a wavelength of 470 nm for 40 s. The tip of light-curing unit was set to touch the celluloid strip.[18,19] Specimens in the Group 1 were immediately tested for their diametral tensile strength using a universal testing machine[20] (Shimadzu, Japan), whereas Group 2 [Figure 1] was immersed in artificial saliva at 37°C for 24 h before diametral tensile strength testing.[9] Diametral tensile strength was tested with a universal testing machine at PT INTEC, Karawang.

Statistical analysis

The normality of the data was tested using the Shapiro–Wilk test, which confirmed normally distributed data ($P > 0.05$). Data analyses were performed using the two-way ANOVA test using SPPS version 20 (IBM, N.Y., USA).

Results

The result of the diametral tensile strength of the three materials tested is varied [Table 1]. The statistical analysis result is shown in Table 2 which confirmed a significant difference in the diametral tensile strength among the three resin materials ($P = 0.000$).

Discussion

Research on the mechanical properties of heated composite resin is important for understanding the effects of heat on the ability of these materials to withstand mastication loads.[13,15] Increasing the temperature of the composite resin escalates the mobility of free radicals and monomers, thereby increasing the monomer conversion. This, in turn, improves the degree of polymerization, as well as the polymer crosslinking, mechanical properties, and physical properties.[14,15] High surface hardness and increased depth of polymerization are other advantages gained by heating composite resins.

The diametral tensile strength is an important factor to examine because it relates to the resistance to lateral forces that occur during mastication.[21] In this study, composite resins were heated according to the recommendations of the heating device, which is 39°C. The composite resin was repeatedly heated up to twenty times because D'Amario *et al.*'s research has indicated that a single composite resin syringe can be used to fill up to twenty cavities, especially when using the multishade layering technique.[17]

Table 1: Descriptive data of the mean and standard deviations of the diametral tensile strength of different composite resins based on time and treatment

Material	Time	Preheated	Mean	SD	*n*
Nanohybrid	24 h	Control	44.50	11.20	10
		10×	42.00	11.47	10
		20×	44.90	8.81	10
	Immediate	Control	30.70	5.63	10
		10×	35.50	5.31	10
		20×	41.10	9.84	10
Nanofill	24 h	Control	34.60	7.48	10
		10×	29.30	3.05	10
		20×	27.20	4.23	10
	Immediate	Control	34.80	2.82	10
		10×	32.40	3.59	10
		20×	35.60	2.27	10
Microhybrid	24 h	Control	46.80	4.54	10
		10×	40.30	5.25	10
		20×	40.40	8.78	10
	Immediate	Control	42.50	7.42	10
		10×	43.60	4.50	10
		20×	46.50	8.46	10

SD: Standard deviation

Table 2: Two-way ANOVA of effects of material, time, and preheating repetitions on diametral tensile strength of the composite resins

	P
Material	<0.01*
Time	0.436
Preheating repetitions	0.206
Material and time	<0.01*
Material and preheating repetitions	0.078
Time and preheating repetitions	0.001*
Material, time, and preheating repetitions	0.949

*Significance: P<0.05

The composite resins in this study are provided in syringes. The temperature of the material is maintained stable by placing heaters near the composite resin molds, with the aim of simplifying and speeding up the processing time while preventing a decrease in temperature during material manipulation. This was suggested by Daronch *et al*., as clinicians must work fast to ensure that only a slight decrease in temperature occurs.[22] The results of previous studies show that the temperature of the composite resin drops rapidly when the syringe is removed from the heater, and the composite resin is taken to the tooth surface.[13]

The microhybrid composite resin in this study showed an increase in diametral tensile strength in the immediately tested group. Nada and El-Mowafy study of microhybrid composite resins showed an increase in the surface hardness of the heated composite resin.[15] The degree of conversion is the percentage of carbon–carbon double bonds that have been converted into a single bond to form a polymeric resin. The higher the degree of conversion, the better the strength, wear resistance, and other important properties related to resin performance.[23] Meanwhile the shrinkage on polymerization related to the cavity configuration.[24]

The nanofill composite resin used in this study had the lowest diametral tensile strength when compared to the nanohybrid and microhybrid composite resins. This is due to the differences in the morphology of the composite resin filler. The nanofill composite resin tested in this study is a composite resin with a filler morphology in the form of prepolymerized fillers. Research by Kim *et al*. found that the amount of filler in composite resins was influenced by the filler morphology. Composite resins that contain prepolymerized filler particles have the lowest amount of filler. This type of composite resin also has the lowest flexural strength compared to composite resin with an irregular filler type or a mixture of prepolymerized and irregular forms.[25]

The microhybrid and nanohybrid composite resins tested in this study have higher diametral tensile strength than nanofill composite resins because hybrid composite resins have smaller filler particles that can enter between large fillers to filling the empty spaces between them, thereby providing better strength. By contrast, the nanofill composite resin has a filler with a rounded shape, which leaves a space among fillers, therefore decreased the strength when compared with the hybrid composite resins.

In this study, an increase and decrease were observed in the tensile strength of diametral nanohybrid, nanofill, and microhybrid composite resin composites after heating ten and twenty times when compared to controls, but the changes were not statistically significant. Research by D'Amario on nanohybrid composite resins also revealed that composite resins retain their same mechanical characteristics after 1, 10, 20, 30, and 40 times heating cycles at 39°C. The mechanical characteristics of the composite resin were not significantly different from those of the unheated composite resin.

The results in this study indicate that the significant difference observed in the diametral tensile strength between the three heated composite resins is likely due to the different filler and monomer contents. Therefore, different materials are likely to have different reactions when heated. In addition, the ability of each material to be heated also plays an important role in the compression strength of the material. Only the nanohybrid composite resins used in this study can be heated, according to their product descriptions.

This study conducted an immediate and 24 h diametral tensile strength tests to determine whether time has an influence on the diametral tensile strength. The results indicated that there are no effects of time on the diametral tensile strength. The choice of treatment time "immediately" after polymerization is important because the operator expects that the restoration will be sufficiently polymerized to endure mastication forces immediately after polymerization. If a time interval is needed for the restoration to accept this force, additional information should be listed in the manufacturer's instructions. However, manual instructions on this subject are not usually provided, but a diametral tensile strength test can immediately be carried out after polymerization.[27]

The 24 h time was chosen because a postcure polymerization occurs due to the photoactivation properties of the composite resin. After polymerization, free radicals trapped in the matrix can continue to react to slowly make bonds over time. Postcure reactions can continue as long as free radicals and reactants (for example, pendant methacrylate groups and free monomers) are still present. In general, postcure polymerization occurs during the first 24 h after polymerization. After 24 h, the amount of free radicals will decrease, and any subsequent polymerization will proceed very slowly.[28-30]

A literature study reveals that no adverse effects occur regarding the mechanical properties of composite resins due to heating procedures.[31] Research by Osternack *et al*. on microhybrid resins concluded that composite resin hardness was not affected by heating or cooling.[32] However, the majority of previous studies did not carry out repeated heating cycles. Daronch *et al*. reported that prolonged heating or ten0 repetitions of heating did not affect the degree of conversion when compared to composite resins maintained at room temperature.[18] A study by D'Amario *et al*. on nanohybrid composite resins revealed that repeated cycles of heating to 39°C did not affect the mechanical properties of composite resins. Heating to 39°C is considered sufficient to increase flowability and better adaptation to composite resins.[17]

Other ways to increase the viscosity of composite resins have been developed, including reducing the viscosity of monomers and using sonic vibrations. The viscosity of monomers can be reduced by combining bisphenol A-glycidyl methacrylate with triethylene glycol dimethacrylate. Sonic vibrations are thought to reduce the viscosity of the resin by increasing the flowability of composite resins.[4]

Besides the temperature of 39°C used in this study, other temperatures can be used for heating composite resin. The Ena Heat heater (Micerium S.p.A, Avegno, GT, Italy) has a heating temperature of 55°C that, according to the manufacturer's instructions, will produce composite resin with high flowability for use in cementation. In addition to the Ena Heat model, another composite resin heater on the market is the Calset (AdDent Inc., Danbury, CT, USA). This tool can heat the composite resin at 54°C and 68°C.

The marginal adaptation of composite resin is significantly better in axial walls when the composite resin is preheated.[6] El-Deeb *et al*. examined the effect of heating composite resin at 54°C and 68°C on the increase in intrapulp temperature and found that heating of composite resin increased intrapulp temperature without endangering the vitality of the pulp.[33]

Apart from the effects of heating on the mechanical properties of composite resins, a debate still exists over the shrinkage that occurs in heated composite resins. Deb *et al*. and Didron *et al*. indicated shrinkage in heated composite resin, but Lohbauer said that any shrinkage that occurred was not significant.[11,12,26]

Conclusion

Repeated heating has different effects on the diametral tensile strength of composite resins with different filler types. The nanohybrid composite resin in this study had the most stable diametral tensile strength after heating compared to nanofill and microhybrid types. The nanofill composite resin in this study had the lowest diametral tensile test compared to the other composite resins.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Amerongen JP, Amerongen WE, Watson TF, Opdam NJ, Roeters FJ, Bittermann D, *et al*. Restoring the tooth: The seal is the deal. In: Fejerskov O, Kidd E, editors. Dental Caries: The Disease and its Clinical Management. 2nd ed. Copenhagen: Blackwell Muksgaard; 2008. p. 393.
2. McCabe JF, Walls AW. Resin based filling material. In: McCabe JF, Walls AW, editors. Applied Dental Materials. 9th ed. Copenhagen: Blackwell Munksgaard; 2007. p. 196-202.
3. Frencken JE, Peters MC, Manton DJ, Leal SC, Gordan VV, Eden E. Minimal intervention dentistry for managing dental caries – A review: Report of a FDI task group. Int Dent J 2012;62:223-43.
4. Baroudi K, Rodrigues JC. Flowable resin composites: A systematic review and clinical considerations. J Clin Diagn Res 2015;9:ZE18-24.
5. Wagner WC, Aksu MN, Neme AM, Linger JB, Pink FE, Walker S. Effect of pre-heating resin composite on restoration microleakage. Oper Dent 2008;33:72-8.
6. Froes-Salgado N, Silva LM, Kawano Y, Francci C, Reis A, Loguercio A. Composite preheating: Effects on marginal adaptation, degree of conversion and mechanical properties. Dent Mater 2010;26:908-14.
7. Wang L, D'Alpino PH, Lopes LG, Pereira JC. Mechanical properties of dental restorative materials: Relative contribution of laboratory test. J Appl Oral Sci 2003;11:162-7.
8. Gömeç Y, Dörter C, Dabanoglu A, Koray F. Effect of resin-based material combination on the compressive and the flexural strength. J Oral Rehabil 2005;32:122-7.
9. Thomaidis S, Kakaboura A, Mueller WD, Zinelis S. Mechanical properties of contemporary composite resins and their interrelations. Dent Mater 2013;29:e132-41.
10. Bartlett D, Sundaram G. An up to 3-year randomized clinical study comparing indirect and direct resin composites used to restore worn posterior teeth. Int J Prosthodont 2006;19:613-7.
11. Lohbauer U, Zinelis S, Rahiotis C, Petschelt A, Eliades G. The effect of resin composite pre-heating on monomer conversion and polymerization shrinkage. Dent Mater 2009;25:514-9.
12. Deb S, Di Silvio L, Mackler HE, Millar BJ. Pre-warming of dental composites. Dent Mater 2011;27:e51-9.
13. Soliman EM, Elgayar IL, Kamar AA. Effect of preheating in microleakage and microhardness of composite resin (an *in vitro* study). Alex Dent J 2016;41:4-11.
14. Uctasli MB, Arisu HD, Lasilla LV, Valittu PK. Effect of preheating on the mechanical properties of resin composites. Eur J Dent 2008;2:263-8.
15. Nada K, El-Mowafy O. Effect of Precuring Warming on Mechanical Properties of Restorative Composites. Int J Dent 2011;2011:1-5.
16. D'Amario M, Pacioni S, Capogreco M, Gatto R, Baldi M. Effect of repeated preheating cycles on flexural strength of resin composites. Oper Dent 2013;38:33-8.
17. D'Amario M, de Angelis F, Vadini M, Marchili N, Mummolo S, D'Arcangelo C. Influence of a repeated preheating procedure on mechanical properties of three resin composites. Oper Dent 2015;40:181-9.

18. Daronch M, Rueggeberg FA, Moss L, de Goes MF. Clinically relevant issues related to preheating composites. J Esthet Restor Dent 2006;18:340-50.
19. Rode KM, Kawano Y, Turbino ML. Evaluation of curing light distance on resin composite microhardness and polymerization. Oper Dent 2007;32:571-8.
20. Bresciani E, Barata Tde J, Fagundes TC, Adachi A, Terrin MM, Navarro MF. Compressive and diametral tensile strength of glass ionomer cements. J Appl Oral Sci 2004;12:344-8.
21. Aguiar FH, Braceiro AT, Ambrosano GM, Lovadino JR. Hardness and diametral tensile strength of a hybrid composite resin polymerized with different modes and immersed in ethanol or distilled water media. Dent Mater 2005;21:1093-203.
22. Daronch M, Rueggeberg FA, Goes MF, Giucidi R. Polymerization kinetics of preheated composite. J Dent Res 2006;85:38-43.
23. Anusavice KJ, Shen C, Rawls HR. Philips' Science of Dental Material. 12th ed. St. Louis (MO): Elsevier; 2013.
24. Oskoee PA, Azar FP, Navimipour EJ, Chaharom ME, Alavi NF, Salari A. The effect of repeated preheating of dimethacrylate and silorane-based composite resins on marginal gap of class V restorations. J Dent Res Dent Clin Dent Prospects 2017;11:36-42.
25. Kim KH, Ong JL, Okuno O. The effect of filler loading and morphology on the mechanical properties of contemporary composites. J Prosthet Dent 2002;87:642-9.
26. Didron PP, Ellakwa A, Swain MV. Effect of preheat temperatures on mechanical properties and polymerization contraction stress of dental composite. Mater Sci App 2013;4:374-85.
27. Schattenberg A, Lichtenberg D, Stender E, Willershausen B, Ernst CP. Minimal exposure time of different LED-curing devices. Dent Mater 2008;24:1043-9.
28. Ayub KV, Santos GC Jr., Rizkalla AS, Bohay R, Pegoraro LF, Rubo JH, *et al*. Effect of preheating on microhardness and viscosity of 4 resin composites. J Can Dent Assoc 2014;80:e12.
29. Par M, Gamulin O, Marovic D, Klaric E, Tarle Z. Effect of temperature on post-cure polymerization of bulk-fill composites. J Dent 2014;42:1255-60.
30. Alshali RZ, Salim NA, Satterthwaite JD, Silikas N. Post-irradiation hardness development, chemical softening, and thermal stability of bulk-fill and conventional resin-composites. J Dent 2015;43:209-18.
31. Schneider LF, Consani S, Ogliari F, Correr AB, Sobrinho LC, Sinhoreti MA. Effect of time and polymerization cycle on the degree of conversion of a resin composite. Oper Dent 2006;31:489-95.
32. Osternack FH, Caldas DB, Almeida JB, Souza EM, Mazur RF. Effects of preheating and precooling on the hardness and shrinkage of a composite resin cured with QTH and LED. Oper Dent 2013;38:E1-8.
33. El-Deeb HA, Abd El-Aziz S, Mobarak EH. Effect of preheating of low shrinking resin composite on intrapulpal temperature and microtensile bond strength to dentin. J Adv Res 2015;6:471-8.

The Effect of Repeated Preheating on Diametral Tensile Strength of Composite Resin with Different Fillers

ORIGINALITY REPORT

16%	10%	13%	5%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to University of Michigan Flint Student Paper	3%
2	"Conference Proceedings for the Fourth International Forum on Quality Cancer Care (IFQCC2020) April 4 and 5, 2020, Abstracts, Queens College, Oxford University, Oxford, UK", Global Journal on Quality and Safety in Healthcare, 2020 Publication	2%
3	Matej Par, Ozren Gamulin, Danijela Marovic, Eva Klaric, Zrinka Tarle. "Effect of temperature on post-cure polymerization of bulk-fill composites", Journal of Dentistry, 2014 Publication	1%
4	www.science.gov Internet Source	1%
5	"Full Issue PDF", Operative Dentistry, 2014 Publication	1%
6	Submitted to Mansoura University Student Paper	1%

7	sciendo.com Internet Source	1 %
8	meridian.allenpress.com Internet Source	1 %
9	Hammouda, I.M.. "Reinforcement of conventional glass-ionomer restorative material with short glass fibers", Journal of the Mechanical Behavior of Biomedical Materials, 200901 Publication	1 %
10	"Full Issue PDF", Operative Dentistry, 2016 Publication	1 %
11	english.shutcm.edu.cn Internet Source	1 %
12	R. N. Swamy. "Fibre Reinforced Cement and Concrete", CRC Press, 1992 Publication	1 %
13	elibrary.stipram.ac.id Internet Source	1 %
14	Maryam Montazerolghaem, Håkan Engqvist, Marjam Karlsson Ott. "Sustained release of simvastatin from premixed injectable calcium phosphate cement", Journal of Biomedical Materials Research Part A, 2014 Publication	1 %