ORIGINAL RESEARCH

Comparative Evaluation of Intrapulpal Thermal Changes during the Polymerization of Different Adhesive Resin Materials: An *In Vitro* Study

Pawankumar Kamalapurkar[1], Pavithra K Ramanna[2], Suneel V Vadavadagi[3], Shreeshail Indi[4], Konsam Bidya Devi[5], Vineetha Chakravarthy Srinivas[6]

Abstract

Aim: Aim of this study was to assess the thermal changes within the pulp at the time of polymerization of three different adhesive resin materials.

Materials and methods: Sixty human premolar teeth that had been recently extracted for orthodontic reasons and were devoid of dental caries/flaws were included in this research. Following preparation of the cavities, all 60 samples consisting of 20 premolars in every group, depending on the adhesive resins that were positioned as were assigned at random to one of the following three groups: Group I: RelyX self-adhesive resin cement; Group II: Breeze self-adhesive resin cement; Group III: Pan F self-etch adhesive resin cement. The temperature changes were calculated using a thermocouple wire attached to a digital thermometer. The dissimilarities amid the baseline temperature as well as the temperatures at different time intervals (1, 5, 10, and 15 minutes) were established.

Results: The thermal value was higher at first minute (1.84 ± 0.34) and gradually reduced at 5 minutes (1.36 ± 0.29), 10 minutes (0.62 ± 0.11), and 15 minutes (0.06 ± 0.03) in RelyX self-adhesive resin cement. The maximum thermal value was found at the first minute (2.66 ± 0.21) and gradually reduced at 5 minutes (1.42 ± 0.13), 10 minutes (0.86 ± 0.09), and 15 minutes (0.28 ± 0.01) in Breeze self-adhesive resin cement. The higher thermal value was found at the first minute (1.98 ± 0.19) and gradually reduced at 5 minutes (1.49 ± 0.14), 10 minutes (0.76 ± 0.10), and 15 minutes (0.16 ± 0.09) in Pan F self-etch adhesive resin cement and there was a statistically significant difference found between various time points and with all three adhesive resin material groups (p <0.001).

Conclusion: This current research arrived at a conclusion that each of the three adhesive resin substances showed a safe temperature change within the pulp. However, the lowest heat scores within the pulp were depicted by RelyX self-adhesive resin in pursuit by Pan F self-etch adhesive resin cement as well as the Breeze self-adhesive resin cement in that order.

Clinical significance: The clinical triumph of a restoration is dependent partially on the method of cementation, which is utilized to establish a connection amid the restoration and the tooth. Temporary and permanent pulp inflammation can be avoided by the decreased temperature changes in the adhesive resin cement at the time of polymerization.

Keywords: Adhesive resin cements, Intrapulpal, Polymerization, Thermal changes.

The Journal of Contemporary Dental Practice (2022): 10.5005/jp-journals-10024-3292

Introduction

The core of the teeth is formed by pulpal tissue that comprises live connective tissue that possesses a susceptible and greatly vascular composition. Owing to the extremely delicate characteristic of the pulp, restorations placed clinically in approximation with the pulp tissue can influence its vitality. Of paramount importance is the amount of heat produced during a restorative procedure. Preparation of teeth, heat-producing setting reactions, and any method employed during a fundamental dental restorative procedure may effortlessly affect the temperature within the pulp.[1]

In the dental practice, the substances that are resinous in nature usually require light curing for polymerization. Such a procedure results in a rise of temperature due to absorbing light energy and a heat-releasing resin polymerization reaction.[2] The rise of temperature can be potentially harmful to the pulp. Such unfavorable effects of temperature fluctuations in the pulp have been concerning for several years.[3]

Pulpal tissue is specialized and executes its vitality at a particular temperature range. A permanent pulp damage can occur with the rise of 5.6°C within the pulp leading to a crucial temperature of 42.5°C. Nevertheless, the temperature threshold holds contentious amid new research. Certain causes of rise in temperature at the level

[1]Department of Prosthodontics, MNR Dental College and Hospital, Sangareddy, Telangana, India

[2]Department of Prosthodontics, Crown and Bridge and Implantology, Vydehi Institute of Dental Sciences and Research Hospital, Bengaluru, Karnataka, India

[3]Department of Prosthodontics, SJM Dental College and Hospital, Chitradurga, Karnataka, India

[4]Department of Conservative Dentistry and Endodontics, Al Badar Rural Dental College and Hospital, Gulbarga, Karnataka, India

[5]Department of Periodontology, Dental College, JNIMS, Porompat, Imphal East, Manipur, India

[6]Department of Conservative Dentistry and Endodontics, Sri Ramakrishna Dental College and Hospital, Coimbatore, Tamil Nadu, India

Corresponding Author: Suneel V Vadavadagi, Department of Prosthodontics, SJM Dental College and Hospital, Chitradurga, Karnataka, India, Phone: +91 9845804642, e-mail: Sunilvvv123@gmail.com

How to cite this article: Kamalapurkar P, Ramanna PK, Vadavadagi SV, *et al*. Comparative Evaluation of Intrapulpal Thermal Changes during the Polymerization of Different Adhesive Resin Materials: An *In Vitro* Study. J Contemp Dent Pract 2022;23(5):539–542.

of the floor of the cavity are cavity preparation, polymerization of lining, and restorative substances, in the presence of/devoid of light-curing procedures.[4]

The temperature rise as a result of polymerization reactions may cause temporary/permanent inflammation of pulp and can also lead to necrosis. In this time-frame, numerous causes influence heat changes in the pulp. A direct association amid the concentration of the light source as well as increase in temperature has been noted. Additionally, a negative association exists among thermal changes and residual dentinal thickness as well as the amount of mineralized dentin. Although dentin exhibits little thermal conductivity, the likelihood for pulpal injury is higher in the deeper cavities as the surface area of dentinal tubules is more.[5] Thus, the current research was performed to contrast and assess the heat changes within the pulp at the time of polymerization of different adhesive resin resources.

Materials and Methods

Preparation of Samples

This study was performed in the Department of Prosthodontics, SJM Dental College and Hospital, Chitradurga, India. Sixty human premolar teeth that had been recently extracted for orthodontic reasons and were devoid of dental caries/flaws were included in this research. The premolars were subjected to storage in 0.2% thymol for a period not exceeding 4 months and then allocated at random to 3 groups constituting of 20 premolars in all. The surface debris was cleansed off with the help of an ultrasonic scaler before the research. The samples were placed in distilled water at a temperature of 37 ± 1°C to make sure sufficient hydration of the dental tissues.

Cavity Preparation

A class I cavity was prepared for every sample premolar on the occlusal surface. The prepared cavity approximately measured 3 mm mesiodistally, 1.5 mm buccolingually, and 2 mm deep. Following the radiographic assessment, the residual dentinal thickness amid the pulpal chamber and the cavity floor (occlusally) was around 1 ± 0.1 mm. A high-speed handpiece as well as a novel usual grit diamond bur (#842, Komet, Lemgo, Germany) was employed for preparing the cavity. The bur was subjected to change following preparation of three cavities.

The radicular portion of teeth was positioned within a self-polymerizing acrylic plastic base that measured 20 mm in diameter and 5 mm in height. A vent that provided entry to a thermocouple wire inside the pulp was made at the mid-portion of this base. This wire was positioned beneath the pulp chamber of the tallest pulpal horn, in touch with dentin. To stabilize the thermocouple wire location and permit the heat conduction from the dentinal surface, silicone transfer complex was instilled in the pulpal chamber.

Following preparation of the cavities, all 60 samples consisting of 20 premolars in every group, depending on the adhesive resins that were positioned as, were assigned at random to one of the following three groups:

- Group I: RelyX self-adhesive resin cement (U200, 3M ESPE, 3M Deutschland GmbH, Germany)
- Group II: Breeze self-adhesive resin cement (Pentron Clinical Technologies, Wallingford, USA)
- Group III: Pan F self-etch adhesive resin cement (Kuraray Noritake Dental Inc., Okayama, Japan)

Source of support: Nil
Conflict of interest: None

Spacers for the resinous cement on dentin in the form of 100-µm thick, teflon sheets (20 mm × 20 mm) with an aperture in the middle were employed. The adhesive resin cement was made to adhere to dentin beneath IPS e.max Press restoration. The resin cement was light-cured at a distance amid the adhesive resin cement and light source of 10 mm. All adhesive resin cements were evaluated at 23 ± 2°C and 50 ± 5% relative humidity.

Evaluation of Intrapulpal Thermal Changes

The temperature changes were calculated using a thermocouple wire attached to a digital thermometer. The emission from a digital thermometer was fed into a chart tracer. Dissimilarities amid the baseline temperature and temperatures at different time intervals (1, 5, 10, and 15 minutes) were established, and the mean temperature changes were measured.

Statistical Analysis

The statistical assessment was conducted employing the IBM SPSS software (Version 20.0, IBM, Armonk, NY, USA). The data were assessed utilizing a one-way analysis of variance (ANOVA) with significance set at 0.05 pursued by a *post hoc* comparative assessment with Tukey's honest significant difference (HSD) test.

Results

Table 1 depicts the mean heat changes within the pulp with use of RelyX self-adhesive resin cement at the time of polymerization. The value of the heat change was found to be greater during the first minute at 1.84 ± 0.34. This eventually decreased at five minutes with a thermal value of 1.36 ± 0.29, then 0.62 ± 0.11 at 10 minutes and 0.06 ± 0.03 at 15 minutes. The difference amid the numerous time intervals and the resin cement was noted to be significant statistically.

Table 2 delineates the mean heat changes within the pulp with use of Breeze self-adhesive resin cement at various time points. The value of the heat change was found to be greatest during the first minute at 2.66 ± 0.21. This eventually decreased at 5 minutes with a thermal value of 1.42 ± 0.13, then 0.86 ± 0.09

Table 1: Mean intrapulpal thermal changes of RelyX self-adhesive resin cement during polymerization process

Adhesive resin cement	*Time points (min)*	*Mean ± SD*	*F*	*p*
RelyX self-adhesive resin cement	1	1.84 ± 0.34	19.317	0.001
	5	1.36 ± 0.29		
	10	0.62 ± 0.11		
	15	0.06 ± 0.03		

Table 2: Mean intrapulpal thermal changes of Breeze self-adhesive resin cement during polymerization process

Adhesive resin cement	*Time points (min)*	*Mean ± SD*	*F*	*p*
Breeze self-adhesive resin cement	1	2.66 ± 0.21	24.289	0.001
	5	1.42 ± 0.13		
	10	0.86 ± 0.09		
	15	0.28 ± 0.01		

Table 3: Mean intrapulpal thermal changes of Pan F: Self-etch adhesive resin cement during polymerization process

Adhesive resin cement	*Time points (min)*	*Mean ± SD*	*F*	*p*
Pan F: Self-etch adhesive resin cement	1	1.98 ± 0.19	20.278	0.001
	5	1.49 ± 0.14		
	10	0.76 ± 0.10		
	15	0.16 ± 0.09		

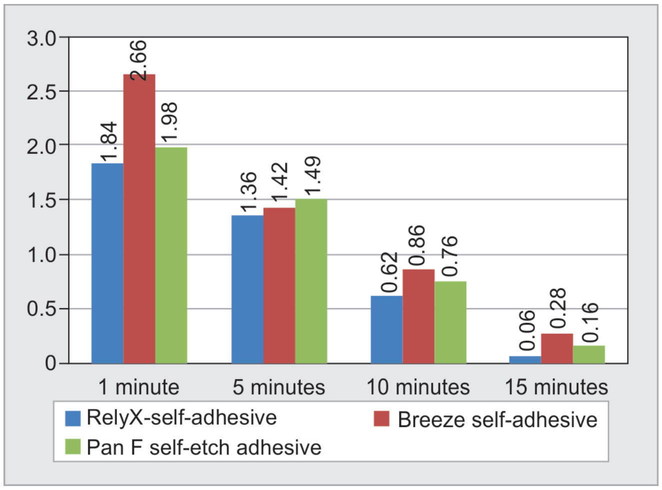

Fig. 1: Intrapulpal thermal changes of all three adhesive resins cement during polymerization process

at 10 minutes and 0.28 ± 0.01 at 15 minutes. The difference amid the numerous time intervals and the resin cement was noted to be significant statistically with $p < 0.001$.

With the use of Pan F self-etch adhesive resin cement, as noted in Table 3, the value of the heat change was found to be higher during the first minute at 1.98 ± 0.19. This eventually decreased at 5 minutes with a thermal value of 1.49 ± 0.14, then 0.76 ± 0.10 at 10 minutes and 0.16 ± 0.09 at 15 minutes. The difference amid the numerous time intervals and the resin cement was noted to be significant statistically with $p < 0.001$ (Fig. 1).

During *post hoc* comparative assessments, there were no significant differences statistically amid the different adhesive resin cements with $p > 0.001$.

The inference of the present study indicates that the least intrapulpal thermal values were showed by RelyX self-adhesive resin followed by Pan F self-etch adhesive resin cement and Breeze self-adhesive resin cement.

Discussion

Recently, the polymerized restorative substances have been of concern especially in deep dental cavities because they decrease the stages needed for applying, and enable filling the cavity using a lone increment of 4–5 mm, thereby decreasing the dental–chair side time. The higher closeness of these restorations to the pulp in deep cavities increases the chances of injury while applying and curing the material. The temperature increase that happens at the time of the restoration procedure can be hazardous to the pulp.[6]

Enhanced temperature within pulp tissue while performing a restoration can have a possible deleterious effect on the vitality of a healthy pulp. Numerous sources for such a temperature rise include preparing a cavity, tooth–bleaching procedure, applying lasers, dental material polishing as well as polymerizing reactions in light-cured substances.[7]

The temperature rise caused by polymerization reaction may be a result of two chief causes: (a) Heat emitted by the light-cure unit while causing polymerization of the dental material and (b) Release of heat during polymerization by the substance itself. The various other contributory causes include quantity of light emitted by the light-cure unit, residual dentin depth, restoration substance constitution, space expanse amid the light-cure unit as well as the restorative substance, location of the light-cure unit, and duration of exposure, which may cause temperature changes in the pulp chamber at the time of polymerization.[8,9]

Heat has been acknowledged as a chief reason for pulp injury. Dentin possesses little heat conductivity; yet, for the period of surplus preparation for restorations, the possibility for pulp damage is higher owing to more dentin tubule surface area. It has been noted that the typical human teeth endure temperatures between –7 and 75°C devoid of injury to the pulp. However, for the duration of the dental management, the temperatures must not be more than 42°C.[10] Hussey et al.[11] arrived at a conclusion that the pulp tissue can be injured when the temperature rises by 5.4 ± 2.5°C at some point in adhesive resin substance polymerization. Nevertheless, Baldissara et al.[12] noted that even a mean rise of 11.2°C has no influence on the pulp.

Nakajima et al.[13] hypothesizes that though dentin has comparatively little heat conductivity, the probability for pulp injury is anticipated to be larger in deep cavities, as the dentin–tubule surface area is augmented causing the light reduction effect to be lesser. Apart from the space among the cavity floor as well as the pulp, the perfusion pace plus the outcomes of the pulp vascularity, the amount and movement of dentine tubule fluid and the neighboring periodontium plays a significant role in thermal conduction and defense against the increase of pulp temperature. As per the imitation research on pulp microcirculation performed by Kodonas et al.,[14] applying heat stimuli greatly persuades temperature increase within the pulp. The result exhibited a 2- or 4 times greater temperature rise within pulp devoid of water perfusion.

In this research, Pan F exhibited the greatest temperature rise in pursuit by RelyX at each time interval investigated. Such an outcome could be attributed to the cementation technique used in Pan F, application of the primer on the surface of the tooth prior to light-curing. The Pan F primer is composed of an auto-etching substance employed in pre-treating the surface of tooth. The pre-treating tooth surface can alter the dentin to become more susceptible to heat changes. As heat effects were lesser than 5.5°C and for a lesser time-period, this temperature rise may not arouse pulp injury. Also, the RelyX set had the least temperature rise scores. This dissimilarity can be because of disparate level of conversion rate of resin or inconsistent magnitude of the resin matrix. These results are in accordance with the research by Al-Qudah et al.[15] who found that resin substances that have higher resin filler amount may lead to lower temperature rise.

The utility of self-adhesive cement has become popular since they do not require any operation on the dentinal surface prior to cementation. Acid-etching, primer, and bond coating stages have been eradicated in self-adhesive resin cement making the process of cementation quicker/simpler. Moszner et al.[16] note that the adhesive characteristics of self-adhesive cement is related to the acidic nature of methacrylate monomer within its configuration.

The monomer offers demineralization as well as micromechanical maintenance by infiltrating into dentin.

The limitations of the present study are that it has been conducted at room temperature in a lab condition, employing a pulpal microcirculation means devoid of fluid movement in the dentinal tubules as well as the adjoining periodontium. The nearby periodontium can additionally encourage thermal convection in clinical circumstances, restraining the temperature changes within the pulp. Consequently, additional research is needed to assess the outcomes of these limitations on the results of our research.

Conclusion

This current research arrived at a conclusion that each of the three adhesive resin substances showed a safe temperature change within the pulp. However, the lowest heat scores within the pulp were depicted by RelyX self-adhesive resin in pursuit by Pan F self-etch adhesive resin cement as well as the Breeze self-adhesive resin cement in that order.

References

1. Oztürk B, Uşümez A, Oztürk AN, et al. *In vitro* assessment of temperature change in the pulp chamber during cavity preparation. J Prosthet Dent 2004;91(5):436–440. DOI: 10.1016/S0022391304001131.
2. Ratih DN, Palamara JE, Messer HH. Temperature change, dentinal fluid flow and cuspal displacement during resin composite restoration. J Oral Rehabil 2007;34(9):693–701. DOI: 10.1111/j.1365-2842.2007.01764.x.
3. Schneider LF, Cavalcante LM, Tango RN, et al. Pulp chamber temperature changes during resin composite photoactivation. Braz J Oral Sci 2005;4(12):685–688. DOI: 10.20396/bjos.v4i12.8641798.
4. Koliniotou-Koumpia E, Dionysopoulos D, Koumpia E, et al. Pulp chamber temperature rise during resin composite polymerization. Balk J Stom 2011;15:150–154. http://balkandentaljournal.com/wp-content/uploads/2016/02/Pulp-chamber-temperature-rise-during-resin-composite-polymerization.pdf.
5. Uhl A, Mills RW, Jandt KD. Polymerization and light-induced heat of dental composites cured with LED and halogen technology. Biomaterials 2003;24(1):1809–1820. DOI: 10.1016/s0142-9612(02)00585-9.
6. Kwon SJ, Park YJ, Jun SH, et al. Thermal irritation of teeth during dental treatment procedures. Restor Dent Endod 2013;38(3):105–112. DOI: 10.5395/rde.2013.38.3.105.
7. Attrill DC, Davies RM, King TA, et al. Thermal effects of the Er:YAG laser on a simulated dental pulp: a quantitative evaluation of the effects of a water spray. J Dent 2004;32(1):35–40. DOI: 10.1016/s0300-5712(03)00137-4.
8. Uzel A, Buyukyilmaz T, Kayalioglu M, et al. Temperature rise during orthodontic bonding with various light-curing units—an *in vitro* study. Angle Orthod 2006;76(2):330–334. DOI: 10.1043/0003-3219(2006)076[0330:TRDOBW]2.0.CO;2.
9. Asmussen E, Peutzfeldt A. Temperature rise induced by some light emitting diode and quartz–tungsten–halogen curing units. Eur J Oral Sci 2005;113(1):96–98. DOI: 10.1111/j.1600-0722.2004.00181.x.
10. Chirtoc M, Bicanic DD, Hitge ML, et al. Monitoring the polymerization process of acrylic resins. Int J Prosthodont 1995;8(3):259–264. PMID: 10348595.
11. Hussey DL, Biagioni PA, Lamey PJ. Thermographic measurement of temperature change during resin composite polymerization *in vivo*. J Dent 1995;23(5):267–271. DOI: 10.1016/0300-5712(95)91149-h.
12. Baldissara P, Catapano S, Scotti R. Clinical and histological evaluation of thermal injury thresholds in human teeth: a preliminary study. J Oral Rehabil 1997;24(11):791–801. DOI: 10.1046/j.1365-2842.1997.00566.x.
13. Nakajima M, Arimoto A, Prasansuttiporn T, et al. Light transmission characteristics of dentine and resin composites with different thickness. J Dent 2012;40(Suppl. 2):e77–e82. DOI: 10.1016/j.jdent.2012.08.016.
14. Kodonas K, Gogos C, Tziafas D. Effect of simulated pulpal microcirculation on intrapulpal temperature changes following application of heat on tooth surfaces. Int Endod J 2009;42(3):247–252. DOI: 10.1111/j.1365-2591.2008.01508.x.
15. Al-Qudah AA, Mitchell CA, Biagioni PA, et al. Thermographic investigation of contemporary resin-containing dental materials. J Dent 2005;33(7):593–602. DOI: 10.1016/j.jdent.2005.01.010.
16. Moszner N, Salz U, Zimmermann J. Chemical aspects of self-etching enamel-dentin adhesives: A systematic review. Dent Mater 2005;21(10):895–910. DOI: 10.1016/j.dental.2005.05.001.