

## ORIGINAL RESEARCH



## Effect of Temperature on Film Thickness of Two Types of Commonly used Luting Cements

<sup>1</sup>M Praveen Kumar, <sup>2</sup>Reddy Priyadarshini, <sup>3</sup>Yasangi M Kumar, <sup>4</sup>K Shanthi Priya, <sup>5</sup>Chunchuvyshnavi, <sup>6</sup>Harika Yerrapragada

### ABSTRACT

**Aim:** The aim of this study is to evaluate the effect of temperature change on film thickness of both types of cements.

**Materials and methods:** Totally, 60 samples were prepared with 10 in each subgroup, thus comprising 30 in each group. Materials tested were glass ionomer cement (GIC) type I and zinc phosphate type I. Samples were manipulated with manufacturer's instructions and tested according to American Dental Association (ADA) guidelines.

**Results:** The mean values of film thickness were recorded for both groups I and II. In intragroup comparison of group 1, subgroup III ( $26.560 \pm 0.489 \mu\text{m}$ ) was found to have the highest film thickness followed by subgroup II ( $24.182 \pm 0.576 \mu\text{m}$ ) and the lowest in subgroup I ( $20.209 \pm 0.493 \mu\text{m}$ ). In intragroup comparison of group II, the film thickness recorded in subgroup III ( $25.215 \pm 0.661 \mu\text{m}$ ) was the highest followed by subgroup II ( $21.471 \pm 0.771 \mu\text{m}$ ) and the least in subgroup I ( $17.951 \pm 0.654 \mu\text{m}$ ;  $p < 0.01$ ). In intergroup comparison of groups I and II, group II ( $21.545 \pm 0.841$ ) was found to have less film thickness than group I ( $23.650 \pm 0.271$ ). The results were found to be statistically significant ( $p < 0.01$ ).

**Conclusion:** Both zinc phosphate and GICs can be used satisfactorily for luting purpose. The temperature fluctuations have a direct influence on the film thickness. Zinc phosphate has less film thickness than GIC.

**Clinical significance:** Zinc phosphate should be preferred over GIC in clinical practice, and more stress should be given in mechanical preparation of crowns for better retentive quality of prosthesis.

**Keywords:** Film, Fluctuations, Luting, Zinc phosphate.

**How to cite this article:** Kumar MP, Priyadarshini R, Kumar YM, Priya KS, Chunchuvyshnavi, Yerrapragada H. Effect of Temperature on Film Thickness of Two Types of Commonly used Luting Cements. J Contemp Dent Pract 2017;18(12):1159-1163.

**Source of support:** Nil

**Conflict of interest:** None

### INTRODUCTION

Various cements are there in the market that claim as having several uses according to their composition, color, and biocompatibility. The word luting means a clay or cement used to seal a joint, coat a crucible, or protect a graft. According to ADA no. 8, dental cement should have a film thickness of 0.25 mm.<sup>1</sup> They serve the purpose of luting indirect restorations, such as crowns, inlays, onlays, and chips to the tooth structure. The cements commonly used for luting purpose include zinc phosphate, GIC, and resin-based cements.<sup>2</sup> The luting of indirect restoration to abutments is the final critical step in achieving proper performance of indirect restoration.<sup>3</sup> Type I zinc phosphate and type I GIC are used for luting purposes.

Zinc phosphate has been used as a standard luting agent for several decades. The zinc phosphate consists of zinc powder and phosphoric acid as liquid. The reaction is basically a chelating type in which phosphoric acid leaches and causes sensitivity in tooth. The GIC is supplied as powder and liquid. Powder comprises glass particles along with fluorine and silica, which formulate fluoroaluminosilicate. Liquid component has polyacrylic acid along with itaconic acid, maleic acid, and tartaric acid. The GIC is also referred to as aluminosilicate polyacrylic acid or polyalkenoate cement.<sup>2</sup>

The GIC is routinely used more in clinical practice than zinc phosphate. The technique-sensitive preparation of teeth has led clinicians to shift their paradigm toward GIC. Film thickness of luting agents is a significant property and an important aspect of restorative

<sup>1,3-6</sup>Department of Prosthodontics, MNR Dental College & Hospital, Hyderabad, Telangana, India

<sup>2</sup>Department of Prosthodontics, GSL Dental College Rajahmundry, Andhra Pradesh, India

**Corresponding Author:** M Praveen Kumar, Department of Prosthodontics, MNR Dental College & Hospital, Hyderabad Telangana, India, e-mail: praveenis@yahoo.com

dentistry. Minimal film thickness will lead to improved casting retention and maintenance of established occlusal relationship.<sup>3</sup> Reduced cement film thickness can also decrease the marginal discrepancies, which, in turn, reduce the plaque accumulation, periodontal disease, and cement dissolution.<sup>4</sup> The GICs have the advantage of being adhesive to both enamel and dentin, which would help retain the casting for a longer period.<sup>5</sup>

The GICs for luting purposes develop their strength by a hardening reaction between ion-leachable glasses and aqueous solutions of homo- and copolymers of acrylic acid.<sup>2</sup>

The physical properties of cements are known to vary under different conditions. Temperature, pressure, moisture, and other external factors may or may not affect the properties of different dental cements used for luting purposes. Null hypothesis states no influence of temperature on film thickness of the luting cements.

**MATERIALS AND METHODS**

This study was conducted to evaluate the effect of temperature on film thickness of two commonly used luting agents, i.e., GIC and zinc phosphate cement (Fig. 1 and Table 1). A total of 60 samples were prepared, with 30 in each group, which were further subdivided into 10 in each subgroup and were used for this study (Table 2). Group I was GIC luting cement and group II was zinc phosphate cement. The study was carried out in accordance to the guidelines of ADA specification no. 8 stating that two glass slabs of 5 cm in length and 2 cm in width were used for the study (Fig. 2). Different temperatures used in the study were 15°C ± 2°C, 25°C ± 2°C, and 35°C ± 2°C. Each glass slab was air-dried, kept over the other glass slab, approximated, and the space between the two glass slabs was measured using metallurgical microscope at the power of ×10.

**Table 1:** Materials used in the study

Material	Trade name	Manufacturer	Batch number
GIC type I	GC luting and lining cement	GC Corporation, 76-1, Hasunuma-Cho, Itabashi-Ku, Tokyo, Japan	1508032
Zinc phosphate cement type I	Zinc F	Prevest Denpro Limited, Unit 1, 38, Industrial Estate, Digiana, Jammu-180010, India	1551702
Glass slides		Recombigen laboratories, Pvt., Ltd., Delhi, India	

**Table 2:** Distribution of samples

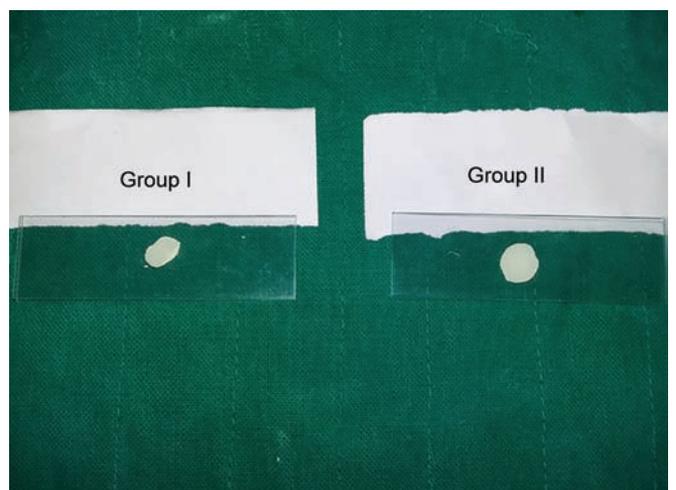
Groups	Subgroups	Description	Number of samples
I	I	GIC prepared in the range of 15 ± 2°C	10
I	II	GIC prepared in the range of 25 ± 2°C	10
I	III	GIC prepared in the range of 35 ± 2°C	10
II	I	Zinc phosphate cement prepared in the range of 15 ± 2°C	10
II	II	Zinc phosphate cement prepared in the range of 25 ± 2°C	10
II	III	Zinc phosphate cement prepared in the range of 35 ± 2°C	10

For zinc phosphate, 1 gm of powder and 0.5 mL of liquid were mixed to a homogeneous consistency in incremental fashion using a stainless steel spatula in a circular fashion to obtain luting consistency and kept on one glass slab. Immediately afterward, another glass slab was kept over the glass slab.

For GIC, two scoops of powder and one drop of liquid were mixed using plastic spatula to obtain luting



**Fig. 1:** Materials used in the study



**Fig. 2:** Experimental setup demonstrating test being carried according to ADA guidelines



**Fig. 3:** Waterbath with thermostat used in the study to regulate temperature

consistency and kept on one glass slab. Immediately afterward, another glass slab was kept over the glass slab. Thus, the luting cement to be tested is sandwiched in between two glass slabs. The entire assembly of glass slabs was kept in a water bath to maintain temperatures of 27 and 40°C (Fig. 3). The temperature of 4°C was maintained by placing assembly in a refrigerator. The glass slab assembly was removed from the water bath and refrigerator and a static load of 20 kg was applied using universal testing machine on the glass slabs for 1 hour and the space present between the two glass slabs was measured using metallurgical microscope at the power of ×10. The test was repeated 10 times for

each subgroup to avoid any chances of bias. Data were collected and statistically analyzed using analysis of variance and Student’s t-test.

**RESULTS**

The study was carried out with the aim to evaluate effect of temperature change on the film thickness of GIC and zinc phosphate cement. The values of film thickness were recorded for each sample and mean values were recorded for both groups I and II. In intragroup comparison of group I, subgroup III (26.560 ± 0.489 μm) was found to have highest film thickness followed by subgroup II (24.182 ± 0.576 μm) and lowest in subgroup I (20.209 ± 0.493 μm; Table 3). In intragroup comparison of group II, the film thickness recorded in subgroup III (25.215 ± 0.661 μm) was highest followed by subgroup II (21.471 ± 0.771 μm) and least in subgroup I (17.951 ± 0.654 μm; Table 4) (p < 0.01).

In intergroup comparison of groups I and II, group II (21.545 ± 0.841) was found to have less film thickness than group I (23.650 ± 0.271). The results were found to be statistically significant (p < 0.01; Tables 5 and 6).

**DISCUSSION**

Dental cements are classified based on the function they provide. The chief function of luting cements is to provide sufficient strength to hold prosthesis or crown in its place. The film thickness has an important role in determining the seating capability of the final restoration. One of the

**Table 3:** Film thickness of group I

Sample	Film thickness (μm) of subgroup I (15 ± 2°C)	Film thickness (μm) of subgroup II (25 ± 2°C)	Film thickness (μm) of subgroup III (35 ± 2°C)
1	20.13	23.75	27.01
2	19.76	24.03	25.86
3	19.34	24.74	27.44
4	20.44	24.59	26.73
5	20.16	23.58	25.99
6	21.01	24.43	26.82
7	19.99	23.16	26.77
8	20.84	24.01	26.13
9	20.01	25.01	26.46
10	20.41	24.52	26.39
X	20.209	24.182	26.560
S	0.493	0.576	0.489
X <sub>ave</sub>	23.650		

**Table 4:** Film thickness of group II

Sample	Film thickness (μm) of subgroup I (15 ± 2°C)	Film thickness (μm) of subgroup II (25 ± 2°C)	Film thickness (μm) of subgroup III (35 ± 2°C)
1	18.27	22.02	25.97
2	18.11	21.97	24.33
3	17.89	21.86	26.01
4	17.33	22.54	24.85
5	19.46	21.65	24.52
6	18.04	20.86	25.98
7	17.96	20.68	25.81
8	17.88	21.01	25.14
9	17.56	22.05	24.65
10	17.01	20.07	24.59
X	17.951	21.471	25.215
S	0.654	0.774	0.661
X <sub>ave</sub>	21.546		

**Table 5:** Analysis of variance for group I

Source	Df	SS	MS	f-value	p-value
Treatment	2	205.916	102.958	379.3460	-0.0000
Errors	27	7.328	0.271		
Total	29	213.244			

SS: Sum of squares; MS: Mean squares; Df: Degree of freedom

**Table 6:** Analysis of variance for group II

Source	Df	SS	MS	f-value	p-value
Treatment	2	263.912	131.956	270.7258	-0.0000
Errors	27	13.160	0.487		
Total	29	277.072			

SS: Sum of squares; MS: Mean squares; Df: Degree of freedom

most common problems encountered in clinical practice is development of high points in crowns after cementation, which were fitting perfect before cementation.<sup>4</sup> The reason for this problem is development of increased film thickness of luting cement used between walls of prosthesis and the tooth prepared.<sup>6</sup> The aim of the present study was to evaluate the film thickness of GIC and zinc phosphate cement and assess influence of temperature on the film thickness of the above said cements. Null hypothesis pointing out that there is no effect of temperature on film thickness stands rejected as a positive interaction was found between all the three subgroups of both groups tested in the study.

The cements tested in the study, i.e., GIC and zinc phosphate cement, are the most common cements used for luting purpose. The GIC is supplied as powder and liquid. Powder comprises glass particles along with fluorine and silica, which formulate fluoroaluminosilicate. Liquid component has polyacrylic acid along with itaconic acid, maleic acid, and tartaric acid. They provide the properties of translucency and esthetics similar to silicates and the property of chemical bonding similar to that of polycarboxylate.<sup>2</sup>

Zinc phosphate cement has zinc oxide and magnesium oxide as powder, and phosphoric acid and zinc stearate as liquid. The bonding to zinc phosphate is purely mechanical. Zinc phosphate is also called as crown and bridge cement because of excellent compressive strength of 104.5 MPa.<sup>2</sup>

The physical properties of cements are known to vary under different temperature conditions. In the present study, the film thickness of GIC and zinc phosphate cement was studied under different temperatures. The temperatures tested were  $15 \pm 2$ ,  $25 \pm 2$ , and  $35 \pm 2^\circ\text{C}$ . The purpose of studying film thickness at three different temperatures is to simulate temperature in winters, air-conditioned dental clinics, and extreme summers. The film thickness was determined by strictly following ADA guidelines having specification no. 8. The standard test for film thickness outlined in ADA specification no. 8 for zinc phosphate cement requires loading of the cement between two glass discs. The film thickness was then determined by subtracting the initial thickness of the two glass discs before loading the cement from their thickness after loading using a micrometer. In this study, the film thickness was measured by placing the cement to be tested in between the two glass plates of  $2\text{ cm}^2$  surface areas. White and Yu<sup>7</sup> used the same technique for measuring the film thickness of the cements tested.

Sadig and Qudami<sup>8</sup> conducted a similar study to investigate the film thickness with a slight modification of ADA technique. They replaced glass discs with plastic discs.

Jorgensen and Petersen<sup>9</sup> reported significant reductions in film thickness when a tapered-pin system was substituted for the method described in ADA specification no. 8. They concluded that the ADA method was a measure of viscosity, whereas their tapered-pin method was a measure of the grain size of the powder and represented a minimal film thickness.

Difference in the temperature altered the film thickness and flow properties of all materials to varying degrees. Both GIC and  $\text{ZnPO}_4$  were mixed strictly following manufacturer's instructions so as to omit any chances of error due to change in powder-liquid ratio.

A total of 60 samples were tested with 30 in each group, which were subdivided in 10 in each subgroup for the study. Film thicknesses of all the samples were recorded and mean film thickness was calculated. One-way analysis of variance and Student's t-test were carried out to check for normality. In intragroup comparison between all the subgroups in groups I and II, subgroup III was found to have the highest film thickness followed by subgroup II and the least in subgroup I. This states that as temperature increases, film thickness also increases leading to more occlusal discrepancies. The result of this study is in accordance with the study by Kern et al<sup>5</sup> who determined the film thickness and the flow rate of the resin cements, self-adhesive resins, and resin-modified glass ionomer luting cements at different temperatures and concluded that cooling increases the fluidity of almost all materials and the effect of the temperature on the film thickness was material dependent. In intergroup comparison between GIC and  $\text{ZnPO}_4$ ,  $\text{ZnPO}_4$  was found to have less mean values of film thickness than GIC.

The results of the present study suggest that though  $\text{ZnPO}_4$  has less film thickness than GIC, both can be used satisfactorily for luting purposes. In addition, GIC is water soluble and erodes from margins giving an advantage to zinc phosphate. The  $\text{ZnPO}_4$  has a compressive strength of 104.5 MPa and GIC type I has a compressive strength of 85 MPa. The  $\text{ZnPO}_4$  has less film thickness than GIC. All these findings suggest that the usage of  $\text{ZnPO}_4$  should be encouraged more than GIC. Since this is an *in vitro* study, other influencing factors, such as intrapulpal temperature,<sup>10</sup> humidity,<sup>11,12</sup> water/powder ratio,<sup>13</sup> and type of preparation<sup>9</sup> are not taken into consideration, which depicts limitations of the present study. It is also suggested to use cool glass slabs to mix dental cements to prolong working time and decrease thickness of the film. Schwartz<sup>14</sup> conducted a similar study and found decreased film thickness while using cold glass slabs. Further studies are directed to study the effect of temperature on film thickness in *in vivo* conditions.

**CONCLUSION**

- Both zinc phosphate and GIC can be used satisfactorily for luting purpose
- The temperature has a direct influence on the film thickness
- Zinc phosphate has less film thickness than GIC.

**REFERENCES**

1. Paffenbarger GC, Beall JR. American dental association specification No. 8 for dental zinc phosphate cement. J Am Dent Assoc 1937 Dec;24(12):2019-2023.
2. Anusavice, K.; Shen, C.; Rawls, HR. Phillips' science of dental materials. 12th ed. India: Elsevier; 2013. pp. 364-395.
3. Kaufman EG, Coelho DH, Colin L. Factors influencing the retention of cemented gold castings. J Prosthet Dent 1961 May-Jun;11(3):487-502.
4. Gavelis JR, Morency JD, Riley ED, Sozio RB. The effect of various finish line preparations on the marginal seal and occlusal seat of full crown preparations. J Prosthet Dent 1981 Feb;45(2):138-145.
5. Kern M, Schaller HG, Strub JR. Marginal fit of restorations before and after cementation *in vivo*. Int J Prosthodont 1993 Nov-Dec;6(6):585-591.
6. Hembree JH Jr, George TA, Hembree ME. Film thickness of cements beneath complete crowns. J Prosthet Dent 1978 May;39(5):533-535.
7. White SN, Yu Z. Film thickness of new adhesive luting agents. J Prosthet Dent 1992 Jun;67(6):782-785.
8. Sadig W, Qudami E. Evaluation of film thickness of new adhesive luting resins. Saudi Dent J 1995;5:157-162.
9. Jorgensen KD, Petersen GF. The grain size of zinc phosphate cements. Acta Odontol Scand 1963 Jun;21:255-270.
10. Khajuria RR, Madan R, Agarwal S, Gupta R, Vadavdgi SV, Sharma V. Comparison of temperature rise in pulp chamber during polymerization of materials used for direct fabrication of provisional restorations: an *in-vitro* study. Eur J Dent 2015 Apr-Jun;9(2):194-200.
11. Zidan O, Ferguson GC. The retention of complete crowns prepared with three different tapers and luted with four different cements. J Prosthet Dent 2003 Jun;89(6):565-571.
12. Ladha K, Verma M. Conventional and contemporary luting cements: an overview. J Indian Prosthodont Soc 2010 Jun;10(2):79-88.
13. Khajuria RR, Singh R, Barua P, Hajira N, Gupta N, Thakkar RR. Comparison of film thickness of two commercial brands of glass ionomer cement and one dual-cured composite: an *in vitro* Study. J Contemp Dent Pract 2017 Aug;18(8):670-674.
14. Schwartz IS. A review of methods and techniques to improve the fit of cast restorations. J Prosthet Dent 1986 Sep;56(3):279-283.