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EFFECT OF AMBIENT TEMPERATURE ON FILM THICKNESS AND TENSILE BOND STRENGTH OF A CONVENTIONAL GLASS IONOMER LUTING CEMENT: AN IN VITRO STUDY

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ABSTRACT

The aim of the study was to evaluate the effect of variation in ambient temperature on film thickness and bond strength of luting GIC. The study was divided into two parts. Each part is divided into three groups according to temperatures; as in group I - $15^0 \pm 2^0$C, group II - $25^0 \pm 2^0$C and group III - $36^0 \pm 2^0$C. For the film thickness, the luting GIC was mixed and placed between the two glass plates and a load of 15 kg was applied for one hour. The space between the glass plates was measured with and without cement by metallurgical microscope at 10x. To evaluate tensile bond strength, extracted permanent mandibular molar was cleaned and prepared with chamfer finish line. Occlusal surface was made flat and the tooth was embedded in auto-polymerized acrylic block. Impression of the tooth was made with copper tube technique and cast was obtained. A casting of dental alloy was fabricated and cemented on the tooth. Tensile bond strength was measured with Instron testing machine. Results showed that the maximum film thickness in group III was 26.78µm, followed by group II 24.52 µm, minimum film thickness was recorded 16.92 µm in group I, a statistical significant difference of $p<0.001$ was seen. The maximum tensile strength was 6.41 MPa for group I followed by 6.11 MPa for group II and minimum was 5.85 MPa in group III, with a statistical significant differences of $p<0.001$. Hence it was concluded that ambient temperature affects the film thickness and bond strength of luting GIC.

KEYWORDS: Bond strength, film thickness, glass ionomer luting cement, ambient temperature metallurgical microscope.

INTRODUCTION

The word luting means a clay or cement used to seal a joint, coat a crucible, or protect a graft. According to ADA specification no. 8, dental cement should have a film thickness of 0.25 mm.[1] They serve the purpose of luting indirect restorations, such as crowns, inlays, onlays, and chips of the tooth structure. The cements commonly used for luting purposes include zinc phosphate, glass ionomer cement (GIC), and resin based cements.[2] The luting of indirect restoration to tooth is the final critical step in achieving proper performance of indirect restorations.[3] Type I conventional GIC is used most commonly for luting purposes. The luting agents may be permanent or temporary depending on their physical properties and the planned longevity of the restoration.[4]

Glass ionomer cement was developed by Wilson and Kent and their coworkers in 1972. Glass is a non crystalline material typically containing silicon. An ionomer is a polymer that comprises repeat units of both electrically neutral repeating units and a fraction of ionized units covalently bonded to the polymer backbone as pendant moieties. It derived from aqueous polyalkenoic acid such as polyacrylic acid and a glass component that is usually a fluoroaluminosilicate. GIC cements are basically supplied in various forms. But conventional GIC is supplied in powder and liquid form. The material is formed by the fusion of quart, alumina, cryolite, fluorite, aluminum trifluoride, and aluminum phosphate at temperature of 1100^0 C - 1300^0 C. This glass frit is cooled to a dull glow and quenched in water. It is subsequently ground and sieved into 45µm size particles. 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. It is also referred as aluminoslicate polyacrylic acid or polyalkenoate cement.[5]

The setting of the GIC can also be influenced by external factors like temperature, humidity, pressure, and mixing time.[6] Film thickness of luting agents is a significant property and an important aspect of restorative dentistry. According to ADA specification no 8, the maximum allowable film thickness for luting cement is 25 µm. Minimal film thickness will lead to improved casting retention and maintenance of established occlusal relationship.[7.8] Reduced cement film thickness can also decrease the marginal discrepancies, which in turn reduce the plaque accumulation, periodontal disease and cement dissolution.[9] An increased film thickness may cause incomplete seating of casting.

Luting agents should provide a durable bond between two material surfaces. The GIC have the advantage of being adhesive to both enamel and dentine, which would help to retain the casting for a longer period.[10,11]

The chemical bonding to the tooth substrate in combination with the fluoride releasing, low coefficient of thermal expansion and the excellent biocompatibility gives GIC an important position in dentistry.[12] On the other hand, the acid- base setting reaction of the GIC still compromises their early strength and initial wear. GIC goes through two stages of setting reactions. The first stage occurs within the first 10 min after mixing, when the material is very susceptible to water uptake. The second stage is a slow and long term continuation of the acid base reaction; when it is susceptible to dehydration.[13] The setting reaction is a continuous process evidenced by the increase in mechanical properties of the cement with time.[14] Thus the premature exposure to water leads to leaching of ions, swelling and weakening, hereas loss of water leads to shrinkage and cracking. Based on these findings more recently, efforts to overcome the dilemma of the water sensitivity have been focused on the properties of setting GIC.[15]

The properties of the dental cements may influenced by the external factors like temperature, pressure, humidity, surface of substrate and the type of bonding.[16,17] Because there is extreme variation of temperatures in India, this study was conducted to evaluate the film thickness and bond strength of a Glass ionomer luting agent at different room temperature as experienced in north India. The aim of this study was to evaluate the effect of different ambient temperature on the film thickness and bond strength of a glass ionomer luting agent as experienced in north India.

MATERIALS AND METHOD

Conventional luting GIC (Hy-Bond Glass Ionomer CX, Shofu Inc, Kyoto, Japan) was used in the study. The present study was divided into two parts. In part1 film thickness and in part 2 bond strength of GIC luting cement was evaluated. Each part is divided into three groups according to the ambient temperature. Group I consist of $15^{0}C\pm2^{0}C$, Group II consist of temp. $25^{0}C\pm2^{0}C$, while Group III contains temperature of $36^{0}C\pm2^{0}C$. Total 60 samples were prepared, with 30 in each part which were further subdivided into 10 in each groups.

Film thickness measurement was done according to ADA specification no.8. Two glass plates of uniform thickness of 5x2 cm were used for the study. Each glass plate was air dried, first measure the space between two glass plates when they are placed atop one another without placing cement in between was measured using metallurgical microscope at the power of 10x.

One scoop of GIC powder and two drops of liquid was mixed to a homogeneous luting consistency using a plastic spatula for 45 sec and was kept on one glass plate of $2cm^2$ area immediately after, another glass slab was kept over the glass plate. Thus the GIC is sandwiched between two glass plates (fig.2). A static load of 15 kg was applied using universal testing machine on the glass plates for one hour (fig.3) and the space present between the two glass plates was measured using metallurgical microscope (DMI Victory, Metzer Optical Instrument, Mathura) at the power of 10 x (fig.4). The difference between the space of two glass plates with and without the cement was considered as film thickness. Each procedure was repeated 10 times for each temperature. All the procedures were carried out strictly in temperature controlled room in winter, summer and air condition room in summer.

To evaluate bond strength, extracted permanent human mandibular first molar tooth without any defect was taken (fig.1). The tooth was cleaned and embedded in auto-polymerized acrylic block (Dentsply, India) and stored in phosphate buffered saline at room temperature. Occlusal surface was made flat and finished with 600 grit silicon carbide paper and chamfer finish line of 0.8 mm wide was prepared. An impression of tooth was made with copper band impression technique and poured with die stone (Kalrock, Kalabhai Karson, Mumbai). After applying die spacer wax pattern (Dentsply, India) of 0.8 mm thickness was made on the tooth. An attachment of 3 mm thick and 13 mm long was attached on occlusal surface and casting was performed using standard techniques with nickel – chromium alloy (Dentslpy, UK). The casting was finished and polished. GIC was mixed according to manufacturer's instructions and applied on the intaglio surface of the casting and placed over conditioned tooth under the static load of 2kg and allowed to set for 24 hour. The sample was tested for tensile bond strength on Instron testing machine (Blue star, India) at a cross head speed of 0.5 mm/min until the bond failure. This test was performed 10 times at each temperature.

RESULTS

All the data recorded and analyzed with the help of the statistical package for social scientist (SPSS) computer software version 20. On normality assessment asymmetry was observed due to lack of sample size, hence a non- parametric ANOVA, Kruskal- Wallis test and Mann – Whitney U test was performed.

Table 1 showed mean film thickness values in different groups. Mean film thickness value was maximum in group III 26.78 MPa followed by 24.52 MPa in Group II. Group I showed minimum film thickness value 16.92 MPa.

Table 1: Film thickness in different groups (µm).

S no.	Group	N	Mean	SD	Min	Max	Median
1.	I	10	16.92	0.75	16.12	18.27	16.81
2.	II	10	24.52	0.71	23.44	25.76	24.30
3.	III	10	26.78	0.46	26.00	27.67	26.75

Table 2: Intergroup comparison of film thickness in different groups – non parametric groups ANOVA.

Group	N	Mean rank
I	10	5.50
II	10	15.50
III	10	25.50
Total	30	

H= 25.806 (df =2); p<0.001

Table 3: Between group comparison of film thickness.

S no	Comparison	Z	P
1.	I vs II	3.780	<0.001
2.	I vs III	3.820	<0.001
3.	II vs III	2.780	<0.001

Table 2: showed film thickness in different groups using Kruskal Wallis test also called non parametric ANOVA where H value was 25.806 i.e statistically significant <0.001.

Mann – Whitney U test between the group comparison showed statistically significant difference in all groups p <0.001 (table3).

This study showed that the film thickness is directly proportional to the temperature, as the film thickness decreases when the temperature decreases and vice versa.

Group 1< Group II< Group III.

Table 4: Intergroup comparison of bond strength (MPa).

S no	Group	N	Mean	SD	Min	Max	Median
1.	I	10	6.41	0.28	6.00	6.70	6.55
2.	II	10	6.11	0.19	5.80	6.40	6.10
3.	III	10	5.85	0.16	5.60	6.10	5.85

Table 5: Intergroup comparison of bond strength in different groups.

Group	N	Mean Rank
I	10	23.00
II	10	16.10
III	10	7.40
Total	30	

H= 15.976 (df=2); p<0.001

Table 6: Between group comparison of bond strength.

S no.	Comparison	Z	P
1.	I vs II	2.210	0.029
2.	I vs III	3.502	<0.001
3.	II vs III	2.670	0.007

Table 4 showed bond StrengthIn different groups; Group 1 showed maximum mean strength 6.41MPa followed by in group II 6.11 MPa and minimum in group III 5.85MPa.

Table 5 showed inter group comparison of bond strength using Kruskal Wallis test also called non parametric ANOVA where H value was 15.976 with 2 degree of freedom was statistically significant <0.001.

Mann – Whitney U test for group comparison between groups showed that the z and p values are significant only in group 1 and group III p< 0.001 while group I and II, and group II and showed no statistically differences p>0.001.

Fig 1: Extracted tooth.

Fig 2: Mixed cement between glass plates.

Fig 3: Static load application.

Fig 4: Tooth preparation.

Fig 5: Metallurgy microscope.

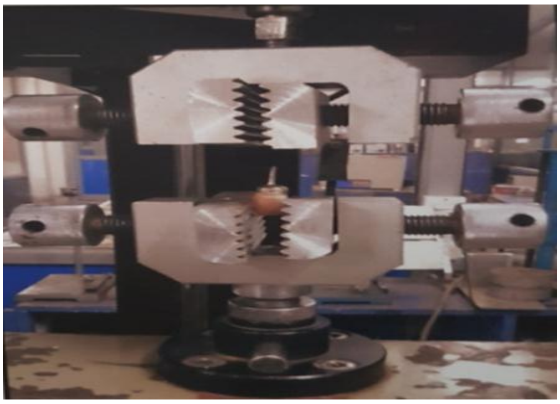

Fig 6: Instron testing machine.

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 in its place. The film thickness has an important role in determining the seating capability of the final restoration. One of the most common problems encountered in clinical practice is development of high points in crown or bridge after cementation, which was fitting perfect before cementation.[18] The reason for this problem is development of increased film thickness of luting cement used between walls of prosthesis and the tooth prepared. The aim of present study was to assess influence of temperature on the film thickness and bond strength of GIC luting cement.

Various authors.[9,19] have conducted their studies at room temperature i.e. 23 $^0\pm2^0$C being the standard room temperature in European countries but in India there is huge differences in temperature in summers and winters. In the present study the film thickness and tensile bond strength of GIC cement was studied under different temperature. The temperatures selected were 15±2, 25± 2, 36±2^0C. The purpose of studying film thickness and tensile bond strength at three different temperatures is to simulate temperature in winters, air conditioned room temperature and extreme summer temperature. The film thickness is strictly following ADA specification no. 8 guidelines. In this study, the film thickness was measured by placing the cement to be tested in between the two glass plates of 2 cm^2 surface areas. White and Yu used the same technique for measuring the film thickness of the cement.[20]

Sadig and Qudami conducted a similar study to investigate the film thickness with a slight modification of ADA technique. They replaced glass discs with plastic discs.[19] Jorgensen and Petersen reported significant reductions in film thickness when a tapered- pin system was substituted for the method described in ADA specification no. 8.[21]

GIC was mixed strictly following manufacturers instruction so to omit any chances of error due to change in powder- liquid ratio. Difference in the powder- liquid ratio altered the film thickness and flow properties of all materials to varying degrees.

A total of 60 samples were tested with 30 in each part, which were subdivided in 10 in each group for the study. Film thickness of all the samples were recorded and mean film thickness was calculated. Kruskal Wallis test also called non parametric ANOVA, and Mann – Whitney U test between the groups comparisons were carried out. In intergroup comparison between all the groups, group III was found to have the highest film thickness followed by group II and least in group I. This states that as temperature increases, film thickness also increases leading to more occlusal discrepancies. The result of the present study is in accordance with the study by Kern et al.[12] Schwartz conducted a similar study and found decreased film thickness while using cool glass slab.[22]

Film thickness of cement was measured between two glass plates with and without cement by the use of metallurgical microscope which is a digital microscope to omit the chances of errors.

Most popular use of GIC is as luting cement due to the chemical bond with the tooth structure and high biocompatibility with living tissues. In principle, conventional glass ionomers are materials that are self adhesives to tooth tissues without any surface treatment. The polyacrylic acid in GICs can have a decalcifying effect on dentine. On this basis, there is no need to pretreat dentine with a decalcifying agent before a GIC is applied.[23] Nevertheless, pretreatment with a weak polyalkenoic acid conditioner significantly improves their bonding efficiency. Therefore, in this study, a conditioner was applied to the dentine surface before the GICs were bonded to the tooth.[24,25]

Retief[26] reported that the storage medium of extracted teeth before test samples preparation is an important factor that influences the results of bond strength studies. Common storage media include formalin, chloramines, ethanol, saline, thymol and sodium azide.[26] In this study, the tooth was stored in phosphate buffered saline at room temperature until they were used at the laboratory.[24,27]

GICs have a double setting reaction whereby the initial setting occurs within the first four minutes. The subsequent reaction is much slower. This second part of the self adhesion mechanism can continue for weeks or even months. Therefore, the timeframe within which GIC dentine shear bond strength is measured is an important consideration. Leirskar et al reported that the bond strength of an improved GIC (Fuji ix) to dentine increased after immersion in water for 8 weeks.[28] Similarly, Wang el al also reported that the bond strength of another improved GIC, Ketec Molar, was not adversely affected after immersion in water at the end of 4 weeks.[29] In this study samples were tested after 24 hours kept without immersion in water.

For bond strength, a natural tooth was flat grounded on occlusal surface, prepared with a chamfer finish line. The tooth flat grounded to provide a uniform thickness of cement between the tooth and crown to be cemented. Preparation was same for all the samples to keep others parameter constant.[30] The impression of the tooth was made using copper band technique to eliminate the chances of any discrepancy. Wax pattern of 0.8 mm with an attachment was made on the occlusal surface of the tooth and casted in nickel chromium alloy.

The highest bond strength was observed in group I, 6.00 MPa followed by in group II, 5.8 MPa and least in group

III 5.60. Decreased bond strength increases the probability of crown dislodgement. These results are in accordance with Patil.[32] Temperature plays an important role in determining the bond strength, as it affects the molecular activity of the luting cement at the time of setting which affects its interaction with the surface to which it is being bonded.

There are some limitations of this study also, this is an in vitro study, other influencing factors, such as intra-pulpal temperature, humidity, powder/ liquid ratio, type of preparation,type of teeth and type of other luting cements are not taken into consideration. Further, long term studies are directed towards in vivo application of the present study and testing of other luting cements for the same parameters.

CONCLUSION

Following conclusion can be drawn

1. Temperature has a significant effect on the film thickness and tensile bond strength of GIC cement
2. The film thickness is directly proportional to temperature
3. The tensile bond strength is inversely proportional to temperature
4. Use cool glass slab for mixing of GIC to decrease film thickness and increase tensile bond strength.

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