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Comparative Evaluation of Solubility of Five Commercially Available Glass Ionomer Luting Cements in Dynamic Artificial Saliva: An *In Vitro* Study

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ABSTRACT

Aim: *To compare solubility of five luting cements namely, GC glass ionomer cement, 3M glass ionomer cement, shofu glass ionomer cement, SDI glass ionomer cement and ivoclar glass ionomer cement in artificial saliva media with two different pH, (pH-5 and pH-7) circulated with magnetic field.* ***Material and methods:*** *Each of the five materials under investigation was used to create a total of 40 specimens, which were then compared for their solubility in an artificial salivary environment. The solubility was determined by calculating the difference between the specimen's initial weight and its final, constant weight after being stored in a desiccator.* ***Results:*** *All glass ionomer luting cements show highest solubility in pH 5 and lowest solubility in pH 7. Among all glass ionomer luting cements GC, 3M, ivoclar and shofu showed highest solubility in pH 5 followed by pH 7, whereas SDI showed highest solubility in both medium pH 5 and pH 7. When solubility was compared with artificial saliva of different pH (pH 5 and pH 7), it was observed that effect of solubility on SDI Glass ionomer luting cement was significantly more than on GC, 3M, ivoclar and shofu glass ionomer luting cements.* ***Conclusion:*** *GC, 3M, shofu, Ivoclar and SDI are more soluble in acidic medium (pH 5) and least soluble in neutral medium (pH 7). GC, 3M, shofu and ivoclar showed least solubility in acidic and neutral pH when compared with SDI. Thus, an important determinant of luting cement in mouth is their resistance to dissolution and disintegration, which is of great importance to clinician in routine dental practice.*

Keywords: Ivoclar, Glass ionomer, Shofu, Disintegration, Dissolution

INTRODUCTION

A crucial stage in the cementation of veneers, crowns, bridges, onlays, and inlays is luting. A luring agent is a substance that, when it solidifies, fills a gap or ties up nearby items. This joint filling should create an impenetrable barrier against the entry of gases and liquids. Deterioration of the luting material at the indirect restoration's circumferential tie creates a stagnation area and micro leakage, which cause periodontal illnesses and recurrent caries [1].

In the repair of teeth with cast restorations, luting cements have been referred to as the "weak link" due to their solubility [2]. Different cements have different characteristics. For this reason, the functional and biological requirements of the particular clinical scenario heavily influence the cement choice. One at the moment, zinc polycarboxylate, zinc phosphate, and glass-ionomer cement are the most often utilized [3].

It is a combination of an alumina silicate glass with an aqueous solution of polyacrylic acid which produces a dental material that possesses: compressive strength greater than zinc phosphate, an adhesiveness to enamel, dentin and cementum, compatibility with the oral tissues and the ability to leach fluoride.

The most successful clinical applications of glass ionomer cement material have been as luting agent [4]. The advantages of glass ionomer cement material include cariostatic activity, bond to tooth structure, high flow characteristics, low solubility [5]. The main disadvantage is moisture sensitivity. Hence, an *in vitro* study has been carried out to discuss and compare the solubility of different commercially available glass ionomer luting cements.

The present study was planned with following objectives

To evaluate the solubility of five commercially available glass ionomer cements *viz*. GC glass ionomer cement, 3M glass ionomer cement, shofu glass ionomer cement, SDI Glass ionomer cement and ivoclar glass ionomer cement after immersion in artificial saliva with pH-5 and pH-7.

To compare the above materials and rate them according to their solubility. The null hypothesis was that there is no difference in the solubility of different commercially available glass ionomer cements.

MATERIALS AND METHODS

A circular mile steel rod was used to create a stainless steel mold. A rod was drilled from the center to create a circular hole surrounded by a metal ring. Using a circular metal mold, 40 specimens in the form of flat circular discs were created from each material.

For GC gold label cement specimens (GC) manipulation was carried out according to manufacturer's instructions in a controlled environment room temperature maintained at 23°C ± 2°C. Pre-weighed powder and liquid was dispensed onto the mixing pad. The pre-weighed powder was divided into two equal half's parts, then liquid was dispensed through syringe. Using agate (plastic) spatula one part of the pre-weighed powder was manipulated for 5 seconds and then remaining part was manipulated for 15 seconds, a total of 20 seconds was utilized to obtain smooth, creamy and glossy consistency of the manipulated cement.

The mix was then inserted into the mold placed on the glass slab, immediately for an hour. microscope glass slide with paper weight was topped on the mixture to extrude excess cement [1]. After hardening, the cement was carefully removed from the mold and was left undisturbed for 24 hours, to ensure adequate strength of the set cement.

Prior to the specimens being exposed to a temperature of 37°C and a relative humidity of 100% for a whole day, each specimen's polished surface was visually inspected for any signs of porosity. The specimens were split up into two-groups, each including twenty samples. Data was recorded based on the random selection and serial numbering of the discs.

The same procedure was carried out for other cements namely Ketac-Cem (3M), Ivoclar, Hy-bond glass ionomer CX (Shofu), Riva Luting cement (SDI).

For the evaluation of solubility, the specimens were immersed in artificial saliva with two different pH (pH-5 and pH-7). The contents of artificial saliva used were: NaCL-0.400 gm, KCl-0.400 gm, $CaCl_2H_2O$-0.795 gm, NaH_2PO_4-0.69 gm, $Na_2S.9H_2O$-0.005 gm, Urea-1.0 gm, Distilled water-1000 ml. The pH was then adjusted to 5 and 7 with NaOH or HCL and volume was made upto 1L.

For measuring solubility, specimens placed in the environment with relative humidity of 100 ± 5% for 24 hours at 37°C were removed and transferred to a desiccator for one hour and weighed using an electronic analytical balance. The specimens were immersed in artificial saliva with two different pH solutions (pH-5 and pH-7) for 10 days.

Media was moved around the specimens using a magnetic field. The specimens were kept in an incubator at 37°C to raise the oral cavity's temperature. For ten days, nothing changed in the media. The specimens were immersed for ten days, and then they were weighed and placed in a desiccator after being blotted with blotting paper to eliminate any visible moisture and loose debris from decomposition. The solubility was determined by measuring the difference between the specimen's original weight and its final, constant weight during desiccator storage.

RESULTS

The data was analyzed using Statistical Package for Social Science (SPSS) version 11.5 (SPSS Inc., Chicago, Ill.). The p value was taken as significant when less than 0.05 (Confidence interval of 95% was taken). The ANOVA test was used to compare the means and the difference between each glass ionomer luting cement and storage solution was assessed by using the Post Hoc test (Tukey test) (Tables 1-5 and Figure 1).

Table 1 Distribution of study sample according to glass ionomer luting cements used

Glass ionomer luting cements	Study sample
GC	40
3M	40
Ivoclar	40
Shofu	40
SDI	40
Total	200

Table 2 Mean solubility of glass ionomer luting cements at pH-5 and pH-7

Solubility	Groups	N	Mean	Std. deviation	Minimum	Maximum
At pH-5	GC	20	0.05	0.01298	0.02	0.07
	3M	20	0.051	0.01447	0.02	0.07
	Ivoclar	20	0.052	0.01436	0.02	0.07
	Shofu	20	0.0515	0.01461	0.02	0.08
	SDI	20	0.0515	0.01387	0.02	0.07
	Total	100	0.0512	0.0138	0.02	0.08
At pH-7	GC	20	0.0335	0.00988	0.01	0.05
	3M	20	0.0315	0.01137	0.01	0.05
	Ivoclar	20	0.0315	0.01137	0.01	0.05
	Shofu	20	0.0335	0.00988	0.01	0.05
	SDI	20	0.032	0.0124	0	0.05
	Total	100	0.0324	0.01084	0	0.05

Table 3 Comparison of solubility of glass ionomer luting cements (ANOVA)

Source	Sum of squares	Sum of squares	df	Mean square	F	Sig.
Solubility at pH-5	Between groups	0	4	0	0.058	0.994*
	Within groups	0.019	95	0		

	Total	0.019	99			
Solubility at pH-7	Between groups	0	4	0	0.173	0.952*
	Within groups	0.012	95	0		
	Total	0.012	99			
Note: *p>0.05 Not significant						

Table 4 Multiple comparison of solubility values among the glass ionomer luting cements by ANOVA and Tukey test at pH-5

Dependent variable	**(I) Sr. no.**	**(J) Sr. No.**	**Mean difference (I-J)**	**Std. error**	**Sig.**
Solubility at pH 5	GC	3M	-0.001	0.00445	0.823
		Ivoclar	-0.002	0.00445	0.654
		Shofu	-0.0015	0.00445	0.737
		SDI	-0.0015	0.00445	0.737
	3M	GC	0.001	0.00445	0.823
		Ivoclar	-0.001	0.00445	0.823
		Shofu	-0.0005	0.00445	0.911
		SDI	-0.0005	0.00445	0.911
	Ivoclar	GC	0.002	0.00445	0.654
		3M	0.001	0.00445	0.823
		Shofu	0.0005	0.00445	0.911
		SDI	0.0005	0.00445	0.911
	Shofu	GC	0.0015	0.00445	0.737
		3M	0.0005	0.00445	0.911
		Ivoclar	-0.0005	0.00445	0.911
		SDI	0	0.00445	1
	SDI	GC	0.0015	0.00445	0.737
		3M	0.0005	0.00445	0.911
		Ivoclar	-0.0005	0.00445	0.911
		Shofu	0	0.00445	1

Table 5 multiple comparison of solubility values among the glass ionomer luting cements by ANOVA and Tukey test at pH 7

Dependent variable	(I) Sr. no.	(J) Sr. no.	Mean difference (I-J)	Std. error	Sig.
Solubility at pH 7	GC	3M	0.002	0.00349	0.567
		Ivoclar	0.002	0.00349	0.567
		Shofu	0	0.00349	1
		SDI	0.0015	0.00349	0.668
	3M	GC	-0.002	0.00349	0.567
		Ivoclar	0	0.00349	1
		Shofu	-0.002	0.00349	0.567
		SDI	-0.0005	0.00349	0.886
	Ivoclar	GC	-0.002	0.00349	0.567
		3M	0	0.00349	1
		Shofu	-0.002	0.00349	0.567
		SDI	-0.0005	0.00349	0.886
	Shofu	GC	0	0.00349	1
		3M	0.002	0.00349	0.567
		Ivoclar	0.002	0.00349	0.567
		SDI	0.0015	0.00349	0.668
	SDI	GC	-0.0015	0.00349	0.668
		3M	0.0005	0.00349	0.886
		Ivoclar	0.0005	0.00349	0.886
		Shofu	-0.0015	0.00349	0.668

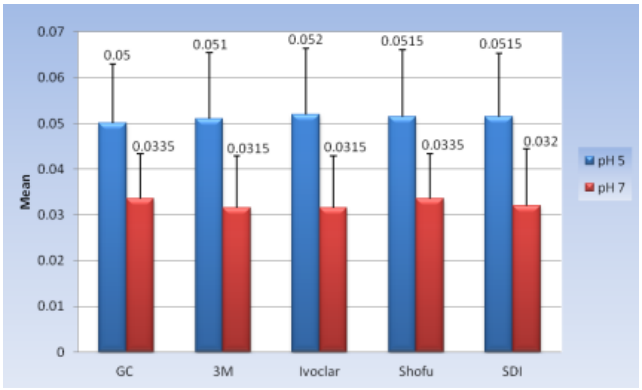

Figure 1 Solubility of glass ionomer luting cement at pH-5 and pH-7

Thus, if we consider the solubility of glass ionomer luting cements at pH-5 and pH-7, then glass ionomer luting cements showed more solubility in pH-5, while glass ionomer luting cement showed less solubility in pH-7.

Among all Glass ionomer luting cements GC, 3M, ivoclar and shofu showed highest solubility in pH-5 followed by pH-7 whereas SDI showed highest solubility in both medium pH-5 and pH-7.

When solubility was compared with artificial saliva of different pH (pH-5 and pH-7), it was observed that effect of solubility on SDI glass ionomer luting cement was significantly more than on GC, 3M, ivoclar and shofu glass ionomer luting cements.

DISCUSSION

A crucial phase in the cementation of veneers, crowns, bridges, inlays, and on lays is luting (changing). The circumferential area, which is the interface of the tooth structure, restoration margin, and luting material, is typically where recurrent caries on the tooth structure is discovered on clinical and radiographic tests. There is evidence of pocket development and both vertical and horizontal bone loss.

This occurs mainly due to dissolution of luting material which has been used for the cementation of the indirect restoration. Most important characteristic required for the luting materials is their resistance to dissolution in oral fluids. Factors that govern the dissolution of the material are the particle size, powder/liquid ratio, mixing technique, contamination, medium pH, exposure time to pH medium and status of oral hygiene.

A number of studies on cement solubility have been carried out *in vitro* and *in vivo* methods. However, the solubility of glass ionomer luting cements in dynamic artificial saliva was unknown. This investigation evaluated and compared the solubility of commercially available luting cements in dynamic artificial saliva.

This investigation evaluated the solubility that occurred when glass ionomer luting cement of GC, 3M, Shofu, SDI and Ivoclar were subjected to immersion in artificial saliva with different pH (pH-5 and pH-7) solutions for period of 10 days.

It is well known that the glass ionomer luting cements become soluble in certain environmental situations. The glass ionomer luting cements that were selected were GC, 3M, shofu, SDI, and ivoclar because these are materials that are frequently utilized in regular dentistry practice to cement prostheses.

Hersek compared *in vivo* solubility of glass ionomer cement with other dental cements and concluded that glass ionomer cement exhibited less solubility than other dental cements [6,7].

Osborne considered a wide range of techniques used in study and variation in condition by specimens *in vivo* on assumption that solubility existed less in glass ionomer cement amongst all materials [8].

Phillips measured intraoral disintegration of four luting cements in two groups of patients During a 12 months period and found glass ionomer cement along which silicophosphate cement showed lower disintegration [9].

Jet test method for solubility has been utilized by some investigators. Other modified methods were developed to copy more clinical situations however most of these tests are static solubility tests unrelated to conditions found in oral environment, and in particular apply only to short-term solubility. In the mouth, luting cements constantly come into contact with oral flow causing dissolution. So, to compare solubility feature of glass ionomer luting cement in current clinical use in artificial saliva media with two different pHs (5 and 7), circulated with magnetic field. It was reported by Norman and Phillips that cements were more soluble in dilute organic acids than in distilled water [10]. Iwaku, Takatsu and Fusaya also concluded that cements were more soluble in acidic medium than in distilled water [11].

CONCLUSION

Dental luting agents provide a link between the restoration and prepared tooth, bonding them together through some form of surface attachment, which may be mechanical, micromechanical, chemical or combination of all. Luting agents may be definitive or provisional depending on their physical properties and planned longevity of the restoration. They provide a link between the restoration and prepared tooth, bonding them together through some form of surface attachment, which may be mechanical, micromechanical, chemical or combination of all.

Solubility is an important feature in assessing the clinical durability of luting cements. Dissolution of cements results in deterioration of restorations, increased marginal leakage and increased potential for secondary caries. Therefore, the study was designed to compare and evaluate the solubility of five commercially available glass ionomer luting cements GC, 3M, shofu, SDI and ivoclar were chosen.

The results revealed that the glass ionomer luting cement showed highest solubility in pH-5 and lowest solubility in pH-7. Among all glass ionomer luting cement GC, 3M, shofu and Ivoclar showed highest solubility in pH-5 followed by pH-7 whereas SDI showed highest solubility in both medium pH-5 and pH-7. Thus, important determinant of luting cement in mouth is their resistance to dissolution and disintegration, which is of great importance to clinician in routine dental practice.

Since this was an *in vitro* investigation, the oral environment could not be precisely replicated. The constant temperature of the medium was a restriction in this investigation because the ambient temperature could alter the bathing medium's density, which could alter the rate of solubility.

The fact that the widely used resin cements were not compared was another drawback. Furthermore, little information has been published regarding how the storage conditions correspond to the therapeutic setting. The solutions used in this investigation represent media that are typical of the oral environment, although they do not take into account all elements to which glass ionomer dental cement may be exposed. Further research is necessary to fully understand how pH influences the solubility of glass ionomer cement in addition to these other parameters.

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