Original Article

DOI: 10.7860/JCDR/2015/12333.6372

Dentistry Section

Comparative Evaluation of Shear Bond Strength of Luting Cements to Different Core Buildup Materials in Lactic Acid Buffer Solution

SIDDHARAM M. PATIL[1], VIKAS B. KAMBLE[2], RAVIRAJ G. DESAI[3], KASHINATH C. ARABBI[4], VED PRAKASH[5]

ABSTRACT

Aim and Objectives: The core buildup material is used to restore badly broken down tooth to provide better retention for fixed restorations. The shear bond strength of a luting agent to core buildup is one of the crucial factors in the success of the cast restoration. The aim of this invitro study was to evaluate and compare the shear bond strength of luting cements with different core buildup materials in lactic acid buffer solution.

Materials and Methods: Two luting cements {Traditional Glass Ionomer luting cement (GIC) and Resin Modified Glass Ionomer luting cement (RMGIC)} and five core buildup materials {Silver Amalgam, Glass ionomer (GI), Glass Ionomer Silver Reinforced (GI Silver reinforced), Composite Resin and Resin Modified Glass Ionomer(RMGIC)} were selected for this study. Total 100 specimens were prepared with 20 specimens for each core buildup material using a stainless steel split metal die. Out of these 20 specimens, 10 specimens were bonded with each luting cement. All the bonded specimens were stored at 37^{0}c in a 0.01M lactic acid buffer solution at a pH of 4 for 7days. Shear bond strength was determined using a Universal Testing Machine at a cross head speed of 0.5mm/min. The peak load at fracture was recorded and shear bond strength was calculated. The data was statistically analysed using Two-way ANOVA followed by HOLM-SIDAK method for pair wise comparison at significance level of $p<0.05$.

Results: Two-Way ANOVA showed significant differences in bond strength of the luting cements ($p<0.05$) and core materials ($p<0.05$) and the interactions ($p<0.05$). Pairwise comparison of luting cements by HOLM-SIDAK test, showed that the RMGIC luting cement had higher shear bond strength values than Traditional GIC luting cement for all the core buildup materials. RMGIC core material showed higher bond strength values followed by Composite resin, GI silver reinforced, GI and silver amalgam core materials for both the luting agents.

Conclusion: Shear bond strength of RMGIC luting cement was significantly higher than traditional GIC luting cement for all core buildup materials except, for silver amalgam core buildup material. RMGIC core material showed highest shear bond strength values followed by Composite resin, GI Silver Reinforced, GI and Silver Amalgam core materials irrespective of luting cements.

Keywords: Endodontic, Luting agent, Restoration

INTRODUCTION

Patients are retaining their natural dentition for longer periods because of improved dental care and successful contemporary endodontic treatment. Clinicians are therefore faced with restoring tooth surfaces compromised by caries, trauma and endodontic treatment. For many patients; this involves the placement of a foundation material to replace lost tooth structure, which then receives an indirect restoration that is cemented into place with luting cement [1]. When the tooth is badly broken down the restoration is done using a core buildup material to restore the bulk and subsequent indirect restoration is fabricated [2]. The amount of remaining tooth structure dictates the type of core buildup that can be used. If the loss of coronal tooth structure is minimal or less than 2/3rd, then restoration of the loss tooth structure by use of any core material serves the purpose. These core buildup restorations provide foundation for the tooth that allows the clinician to create favourable retention and resistance forms during the preparation phase of the treatment [3]. Thus core material is a crucial factor in the success of an indirect restorations. Numerous materials have been developed for the use of core restorations like cast cores, silver amalgam, composite resin, glass ionomer, silver reinforced glass ionomer, resin modified glass ionomer, porcelain and compomer [4].

The core buildup material should have desirable properties like sufficient compressive strength, flexural strength, biocompatibility with surrounding tissues and should also have good bond with tooth structure, pins, posts and luting cement. The success of cast restorations depends on important factors such as design and quality of tooth or core material and accuracy of the casting. Factors like the type of core material, biophysical characteristic of luting cement and the degree of bond strength between the luting cement and core materials contributes to the longevity and success [4].

The shear bond strength of luting agents to various core buildup materials should be within the range of clinical acceptability [5]. The water uptake leading hygroscopic expansion and dissolution or the restoration margin affects the bond strength of luting agent to core materials. It is reported that greater erosion in acidic storage media is seen in water based cement and a hygroscopic expansion is seen in resin based cement [6]. Immersion in lactic acid has been used effectively to evaluate the effect of acidic media on cements [6-9]. Acidic condition can occur in the oral cavity because of ingestion of acidic drinks, food or by degradation of polysaccharides. Thus, acid is of great clinical significance. There are various studies reported in the literature regarding the tensile bond strength of various luting cements with core buildup materials [6,10,11]. Fewer studies have dealt with the bond strengths of luting cements to core buildup materials in terms of shear strength characteristics [1,12]. So, the purpose of this invitro study was to evaluate and compare the shear bond strength of two luting agents with five different commonly used core buildup materials in lactic acid buffer solution.

MATERIALS AND METHODS

For the preparation of specimens the metal die was made as suggested by WE Dilts et al., in which mold size of dimension 0.25 inch in diameter, and 0.75 inch in length was fabricated [12]. A removable metal spacer of dimension 0.25 inch in diameter and 0.11 inch in length was also fabricated to create space for luting cement. The metal spacer was placed in the metal die and all the core build-up materials i.e. Silver Amalgam (DPI Alloy Fine grain, Mumbai), Glass ionomer (GC-Gold Label, High strength posterior restorative, Tokyo/Japan), Glass Ionomer Silver Reinforced (HI DENSE, SHOFU-INC, Kyoto/Japan), Composite Resin (Filtek 2350 XT, 3M ESPE), and Resin Modified Glass Ionomer (Vitremer™ Core Buildup, 3M ESPE) were proportioned and manipulated according to manufacturer's instructions and packed into the stainless steel metal die mold [Table/Fig-1]. A uniform load of 500gms was applied on the die until the materials were set. After the final setting of core build up materials, they were gently removed from the mold cavity and the end of the core material specimens which faced towards metal spacer was finished with 320 grit silicon carbide paper, to make it flat for bonding. The surface was then cleaned with air-water spray and dried with air for 10 seconds to simulate clinical treatment of cores. In this manner, 100 specimens were fabricated, out of these specimens, 20 specimens of each core buildup material were randomly divided into two groups (n=10) for luting with each brand of luting cement i.e. Traditional GIC (KetacTMcem Radiopaque,3M ESPE Dental Products) or Resin Modified Glass Ionomer luting cement (RelyX™ Hybrid Glass Ionomer Permanent Luting cement, 3M ESPE Dental Products). The core buildup samples were reinserted into the metal mold and the metal spacer was removed. Each brand of luting cement was mixed according to manufacturer's instructions. The mixed cement was bonded to the core material by expressing it into the space left for luting cement in the mold. A uniform load of 500gms was applied on the die until the luting materials were set. After setting of luting cement, the bonded specimens of total dimension 0.75 inch in length and 0.25 inch in diameter of core build-up material and luting cement were carefully removed from the mold and were examined carefully and if any, faulty specimens were discarded. To stimulate the oral conditions, all the bonded specimens were stored at 37^{0}C in a 0.01M lactic acid buffer solution at a pH of 4 for 7days. The preparation of 0.01 M lactic acid buffer solution of pH4, was done by adding 100ml of distilled water (H_20) to 1ml of lactic acid and adding pellets of sodium hydroxide to maintain the pH at 4 [1]. The lactic acid buffer solution was changed daily.

After seven days of immersion the specimens were removed and thoroughly cleaned and dried. The shear bond strength test was done using Universal testing machine (Unitek 9450 PC). The specimen was positioned horizontally within the specimen holder. Shear load was applied at 90^0 at the junction of luting agent and core material at a cross head speed of 0.5mm/min till it fractures. The values were recorded in a digital readout in Kilo Newton (KN) and were converted to MPa. The shear bond strength megapascals (Mpa) was calculated by dividing the force required to break the specimen by the core buildup-luting agent bond area (0.0492 inches^2).

STATISTICAL ANALYSIS

The obtained data was statistically analysed using Two-way ANOVA followed by HOLM-SIDAK method for pair wise comparison at a significance level of <0.05.

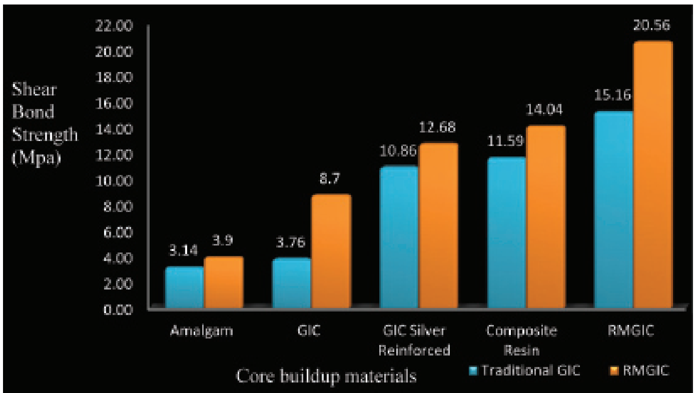
RESULTS

The Shear bond strength values of Traditional GIC luting agent with Silver Amalgam, GI, GIC Silver Reinforced, Composite Resin and RMGIC were 3.14, 3.76, 10.86, 11.59, and 15.16 Mpa with standard deviation of 0.71, 0.52, 1.83, 0.96 and 0.98 respectively. The Shear bond strength values of RMGIC luting agent with Silver amalgam, GIC, GIC Silver Reinforced, Composite Resin and RMGIC were 3.90, 8.70, 12.68, 14.04, 20.56 Mpa with standard deviation of 0.69, 0.57, 1.06, 0.67 and 2.25 respectively [Table/Fig-2].

Two-Way ANOVA showed significant difference in bond strength of luting agents (p<0.05) and core materials (p<0.05) and the interactions (p<0.05) [Table/Fig-3]. When pair wise comparison was done by HOLM-SIDAK test, then the RMGIC luting cement showed significantly higher shear bond strength values (p<0.05) than Traditional GIC luting cement for all the core buildup materials except for silver amalgam core buildup materials (p-0.9039). When core buildup materials were compared in Traditional GIC luting cement group, RMGIC core material showed highest shear bond strength followed by composite resin, GI silver reinforced, GI, and silver amalgam core materials. The difference was statistically significant (p<0.05) for all core buildup materials except between silver amalgam and GIC (p-0.9716) and GI silver reinforced and composite resin core buildup materials (p-0.9204) [Table/Fig-4]. When core buildup materials were compared in RMGIC luting cement group, RMGIC core material showed highest shear bond strength followed by composite resin, GI silver reinforced, GI, and silver amalgam core materials. The difference was statistically significant (p<0.05)) for all core buildup materials except between GI silver reinforced and Composite resin core buildup materials [Table/Fig-5].

S. No.	Material		Brand name	Batch no./ Lot no.	Manufacturer
1	Core Buildup Materials	a) Silver Amalgam	DPI Alloy Fine Grain	4132	Dental Products of India, Bombay
		b) GI	GC-Gold Label, High strength Posterior Restorative	1201131	GC Corporation Tokyo, Japan
		c) GI Silver Reinforced	HI DENSE, Glass Ionomer Silver Reinforced Restorative	011310	SHOFU-INC Kyoto/Japan
		d) Composite Resin	Filtek Z350 XT	N370872	3M ESPE AG Dental Products
		e) RMGIC	Vitremer™ Core Buildup	N490769	3M ESPE Dental Products
2	Luting Agents	a)Traditional Glass Ionomer luting cement	Ketac™cem Radiopaque	505001	3M ESPE Dental Products
		b) Resin Modified Glass Ionomer luting cement	RelyX™ Hybrid Glass Ionomer Permanent Luting cement	N507785	3M ESPE Dental Products

[Table/Fig-1]: Materials used in this study



[Table/Fig-2]: Shear bond strength (Mpa) of core materials with Traditional GIC and RMGIC

DISCUSSION

The choice of core foundation materials is confusing and the physical and handling properties may lead the clinician to favour one material over another. Ultimately, a core build-up must be able to withstand the forces of mastication and parafunction over a period of many

Sources of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F-value	p-value
Main Effects					
Core materials	4	2560.2385	640.0596	476.4904	0.00001*
Luting agents	1	235.7914	235.7914	175.5341	0.00001*
2-Way Interaction Effects					
Core materials x Luting agents	4	81.1950	20.2987	15.1113	0.00001*
Error	90	120.8951	1.3433		
Total	99	2998.1200			

[Table/Fig-3]: Two-way ANOVA for Luting Agents and Core buildup Materials
*p<0.05.

Luting Agent	Core Material	Comparison	p-value	Level of significance
Traditional GIC	Silver Amalgam	GI	p=0.9716	Not Significant
		Silver GI	p=0.0002*	Significant
		Composite Resin	p=0.0002*	Significant
		RMGIC	p=0.0002*	Significant
	GI	Amalgam	p=0.9716	Not significant
		Silver GI	p=0.0002*	Significant
		Composite Resin	p=0.0002*	Significant
		RMGIC	p=0.0002*	Significant
	GI Silver Reinforced	Amalgam	p=0.0002*	Significant
		GI	P=0.0002*	Significant
		Composite Resin	p=0.9204	Not Significant
		RMGIC	p=0.0002*	Significant
	Composite Resin	Amalgam	p=0.0002*	Significant
		GI	p=0.0002*	Significant
		Silver GI	p=0.9204	Not Significant
		RMGIC	p=0.0002*	Significant
	RMGIC	Amalgam	p=0.0002*	Significant
		GI	P=0.0002*	Significant
		Silver GI	p=0.0002*	Significant
		Composite Resin	p=0.0002*	Significant

[Table/Fig-4]: Comparison of five core materials with Traditional GIC luting cement
*p<0.05.

Luting Agent	Core Material	Comparison	p-value	Level of significance
RMGIC	Silver Amalgam	GI	p=0.0002*	Significant
		Silver GI	p=0.0002*	Significant
		Composite Resin	p=0.0002*	Significant
		RMGIC	p=0.0002*	Significant
	GI	Amalgam	p=0.0002*	Significant
		Silver GI	p=0.0002*	Significant
		Composite Resin	p=0.0002*	Significant
		RMGIC	p=0.0002*	Significant
	GI Silver Reinforced	Amalgam	p=0.0002*	Significant
		GI	p=0.0002*	Significant
		Composite Resin	p=0.2222	Not Significant
		RMGIC	p=0.0002*	Significant
	Composite Resin	Amalgam	p=0.0002*	Significant
		GI	p=0.0002*	Significant
		Silver GI	p=0.2222	Not Significant
		RMGIC	p=0.0002*	Significant
	RMGIC	Amalgam	p=0.0002*	Significant
		GI	p=0.0002*	Significant
		Silver GI	p=0.0002*	Significant
		Composite Resin	p=0.0002*	Significant

[Table/Fig-5]: Comparison of five core materials with RMGIC luting cement
*p<0.05

years [13,14]. Cementation is one of the final steps in the sequence of clinical procedure for indirect restorations. Luting agents comprise a broad category of materials used to attach and seal dental restorations and prostheses to teeth. Proper selection of a luting agent is a last important decision in a series of steps that require meticulous execution and will determine the long-term success of fixed restorations. The choice of a luting agent is dependent on the clinical situation combined with the physical, biologic, and handling properties of the luting agent. Currently, a plethora of luting agents is available and the choice of the optimal luting agent can be confusing, even for the most experienced clinician.

The bond strength of a luting agent to dentin or core buildup material is one of the important factors in the success of cast restoration and it should be within the range of clinical acceptability. As most of the failures of indirect restorations occur in the shear stress so in this study, the methodology used to access bond strength was the shear test as previously used by Tezvergil A et al., and Padipatvuthikul P et al., [15,16]. Sinhoreti MA et al., stated that devices like Chisel systems i.e. straight or saddle shaped chisel, stainless steel tape and piston can be used to platform the shear bond strength test [17]. In the present study ISO specified straight chisel of 5mm width was used to perform the test. In this study all the direct core materials i.e. Silver Amalgam, Glass ionomer, Glass Ionomer Silver reinforced, Composite and Tri-Polymerized Resin modified glass ionomer were selected because of their advantages like reduced chair side time, ease of manipulation and reduced cost.

Glass ionomer cements are arguably one of the most popular materials for permanent cementation [18]. But it is said that their mechanical strength is inadequate for use in stress bearing areas. Doubts have been raised regarding the cements cohesive ability to withstand the high stresses generated during contraction on setting invitro, when bonded in thin layers between two substrates. To improve the physical properties and to reduce the chances of cements cohesive failure the resin modified glass ionomer cements were developed. This innovation helped to overcome the problems associated with traditional glass ionomer cements i.e. moisture sensitivity and low physical properties. Considering this fact, traditional glass ionomer luting cement and resin modified glass ionomer luting cement were used as luting agents in this study.

Kuybulu FI et al., stated that water uptake can lead to hygroscopic expansion and dissolution at restoration margins affecting the bond of luting cements to foundation materials [6]. It is believed by some investigators that the rate of disintegration in the dilute organic acids common to the oral cavity could provide data which are more meaningful clinically than in distilled water or artificial saliva [19]. Also, when used for luting, the cement around the margins of restorations is in stagnation area and therefore subjected to pH lower than 7 through the action of bacterial plaque or sugars to produce, in particular, lactic acid [20]. According to the study done by Sandra Hewlett et al., [1] the shear bond strength of the core materials to various luting agents was significantly reduced after immersion in 0.01 M Lactic acid as compared to those stored in 100% humidity. So in this study lactic acid buffer solution of 0.01 M at pH 4 was used rather than distilled water or artificial saliva. This was done to simulate the in vivo conditions. The lactic acid of pH 4 was used based on the previous invitro studies [9,20-27].

Results of this invitro study showed that RMGIC luting cement showed more shear bond strength more than Traditional GIC luting cement. The difference in shear bond strength of the luting cements was statistically significant for all the core buildup materials except for silver amalgam core material. This may be because both the luting agents behaved in similar fashion to achieve just mechanical retention with the amalgam core. The superior shear bond strength of RMGIC luting cement may be because of its resin component which is added to enhance the mechanical and bonding properties and as the physical and mechanical properties are enhanced it reduces the chances of cohesive failure thus increasing the bond strength. The superior shear bond strength can also be attributed to the more water resistance during setting and less solubility than traditional GIC luting cements [28]. Mclean JW and Um CM stated that the main drawback of traditional GIC luting cement is susceptibility to moisture attack & subsequent solubility, if exposed to water during initial setting period [29,30]. The reduced shear bond strength may also be because of absence of resin component and reduced physical and mechanical properties. Similar results were seen in study done by Sandra Hewlett et al., [1].

These results were not in agreement with the findings of Czar Necka & Nicholson who concluded in their study that the presence of the resin phase in the resin modified glass ionomer has little or no effect on the overall interaction with aqueous medium [7]. The non significant difference in the shear bond strength for silver amalgam core material may be because both the luting agents behaved in similar fashion to achieve just mechanical retention with the amalgam core.

When the core materials were compared, irrespective of luting cements, the highest bond strength value was showed by RMGIC core material followed by Composite Resin, GI Silver Reinforced, GI and Silver amalgam. The difference in shear bond strength of Traditional GIC luting cement was statistically significant for all core buildup materials except between silver amalgam with GI and GI silver reinforced with composite resin core buildup material, and the difference in shear bond strength of RMGIC luting cement was statistically significant for all core buildup materials except between GI silver reinforced with Composite resin core buildup materials. The results of this investigation showed that RMGIC core foundations bonded to RMGIC luting cements provide the most durable combination, while silver amalgam core foundation material bonded to traditional GIC luting cement provided the least durable combination in the presence of lactic acid buffer solution. RMGIC core material showed superior shear bond strength with RMGIC luting cement because it is expected that the combination of materials of similar composition will have better bond both by mechanical retention and chemical adhesion. This result was in consistent with the findings by the study done by Sandra Hewlett [1].

Considering the result of this study it can be stated that while restoring the broken down and endodontically treated teeth, the bond strength between a core material and cement should be considered. But because clinical situations usually involve foundations composed of both restorative materials and tooth structure, the results of these studies do not endorse any core material and/or luting cements. Moreover, this invitro study evaluated the bond strength of the luting agents with different core materials by shear test, but according to some investigators that both shear and tensile bond strength are relevant for retention of indirect cement retained restorations. Further investigations are required to evaluate the bonding under more closely simulated clinical conditions.

CONCLUSION

Within the limitations of this invitro study it was concluded that, amongst both the luting cements, the shear bond strength of resin modified glass ionomer luting cement was significantly higher than traditional glass ionomer luting cement for all the core buildup materials except, for silver amalgam core buildup material. Amongst all core buildup materials, resin modified glass ionomer core material showed highest shear bond strength values followed by composite resin, glass ionomer silver reinforced, glass ionomer and silver amalgam core materials irrespective of luting cements.

REFERENCES

[1] Hewlett S, Wadenya RO, Mante FK. Bond Strength of Luting Cements to Core Foundation Materials. *Compendium of Continuing Education in Dentistry*. 2010;31(2):140-46.
[2] Combe EC, Shaglouf A, Watts DC, Wilson NHF. Mechanical Properties of Direct Core Build-up Materials. *Dental Materials.* 1999;15:158–65.
[3] Shillingburg HT, Hobo S, Whitsett SE, Grundlagen der Kronen und Bru¨ckenprothetik. Fundamentals of Fixed Prosthodontics (Ed 2) Berlin, Germany. *Quintessenz.* 1986:67-125.
[4] Bayindir YZ, Bayindir F, AKYIL MS. Bond Strength of Permanent Cementing cost to Crown Different core Build-up Materials. *Dental Materials Journals.* 2004;23(2):117-20.
[5] Fusayaina T, Iwamoto T. Optimum cement film thickness for maximum shear resistance between teeth and restoration. *Bull Tokyo Med Dent Univ.* 1961;8:147.
[6] Kuybulu FI, Gemalmaz D, Pameijer CH. Erosion of luting cements exposed to acidic buffer solutions. *Int J Prosthodont*. 2007;20(5):494-95.
[7] Czarnecka B, Nicholson JW. Ion release by resin-modified glass-ionomer cements into water and lactic acid solutions. *J Dent*. 2006;34(8):539-43.
[8] Nicholson JW, Gjorgievska E, Bajraktarova B. Changes in properties of polyacid-modified composite resins (compomers) following storage in acidic solutions. *J Oral Rehabilitation.* 2003;30(6):601-07.
[9] Fukazawa M, Matsuya S, Yamane M. The mechanism for erosion of glass-ionomer cements in organic-acid buffer solutions. *J Dent Res*. 1990;69(5):1175-79.
[10] Chan KC, Azarbal P, Kerber PE. Bond strength of cements to crown bases. *The Journal of Prosthetic Dentistry.* 1981;46(3):297.
[11] Nayakar RP, Patil NP, Lekha K. Comparative Evaluation of Bond Strengths of Different Core Materials with Various Luting Agents Used for Cast Crown Restorations. *J Indian Prosthodont Soc.* 2012;12(3):168–74.
[12] Dilts WE, Duncanson MG, Miranda FJ, Brackett SE. Relative shear bond strengths of luting media with various core materials. *J Prosthet Dent.* 1985;53(4):505-08.
[13] Yettram AL, Wright KW, Pickard HM. Finite element stress analysis of the crowns of normal and restored teeth. *J Dent Res.* 1976;55:1004-11.
[14] Ho MH, Lee S, Chen HH. Three-dimensional finite element analysis of the effects of posts on stress distribution in dentin. *J Prosthet Dent.* 1994;72:367-72.
[15] Tezvergil A, Lassila LV, Vallittu PK. Composite-composite repair bond strength: Effect of different adhesion primers. *J Dent.* 2003;31:521-25.
[16] Padipatvuthikul P, Mair LH. Bonding of composite to water aged composite with surface treatments. *Dent Mater.* 2007;23: 519-25.
[17] Sinhoreti MA, Consani S, De Goes MF, Sobrinho LC, Knowles JC. Influence of loading types on the shear strength of the dentin-resin interface bonding. *J Mater Sci Mater Med.* 2001;12:39-44.
[18] Materials for Adhesion and Luting. Craig's Restorative Dental Materials. Chapter 13.
[19] Norman RD, Swartz ML, Philips RW, Virmani R. A comparison of the intraoral disintegration of three dental cements. *JADA.* 1969;78:777-82.
[20] Fukazawa M, Matsuya S, Yamane M. Mechanism for Erosion of Glass-ionomer Cements in an Acidic Buffer Solution. *J Dent Res.* 1987;66(12):1770-74.
[21] Beech DR, Bandyopadhyay S. A new laboratory method for evaluating the relative solubility and erosion of dental materials. *Journal of Oral Rehabilitation.* 1983;10:57-63.
[22] Knobloch LA, Kerby RE, McMillen K, Clelland N. Solubility and sorption of resin-based luting cements. *Operative Dentistry.* 2000;25:434-40.
[23] Mesu FP. Degradation of luting cements measured in vitro. *Journal of Dental Research.* 1982;61:665-72.
[24] Murakami H, Matsuya Y, Matsuya S. Dissolution mechanism of zinc phosphate dental cement in acetic and lactic acid buffers. *Biomaterials.* 1990;11:435-40.
[25] Nomoto R, McCabe JF. A simple acid erosion test for dental water-based cements. *Dental Materials.* 2001;17:53-59.
[26] Walls AW, McCabe JF, Murray JJ. An erosion test for dental cements. *Journal of Dental Research.* 1985;64:1100-04.
[27] Yoshida K, Tanagawa M, Atsuta M. In vitro solubility of three types of resin and conventional luting cements. *Journal of Oral Rehabilitation*. 1998;25:285-91.
[28] Wilson AD. Resin-modified glass-ionomer cements. *Int J Prosthodont.* 1990;3:425-29.
[29] McLean JW. Glass-ionomer cements. *Br Dent J.* 1988;164:293-300.
[30] Um CM, Øilo G. The effect of early water contact on glass-ionomer cements *Quintessence Int.* 1992;23:209-14.

PARTICULARS OF CONTRIBUTORS:
1. Senior Lecturer, Department of Prosthodontics, Crown and Bridge, P.M.N.M. Dental College and Hospital, Bagalkot, Karnataka, India.
2. Professor and Head, Department of Prosthodontics, Crown and Bridge, P.M.N.M. Dental College and Hospital, Bagalkot, Karnataka, India.
3. Professor, Department of Prosthodontics, Crown and Bridge, P.M.N.M. Dental College and Hospital, Bagalkot, Karnataka, India.
4. Reader, Department of Prosthodontics, Crown and Bridge, P.M.N.M. Dental College and Hospital, Bagalkot, Karnataka, India.
5. Prosthodontist, Department of Prosthodontics, Crown and Bridge, P.M.N.M. Dental College and Hospital, Bagalkot, Karnataka, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Vikas B. Kamble,
Professor and Head, Department of Prosthodontics, Crown and Bridge, P.M.N.M. Dental College and Hospital,
Bagalkot, Karnataka-587101, India.
E-mail: drvikaskamble2002@yahoo.co.in

FINANCIAL OR OTHER COMPETING INTERESTS: None.

Date of Submission: **Nov 28, 2014**
Date of Peer Review: **Feb 27, 2015**
Date of Acceptance: **Jun 04, 2015**
Date of Publishing: **Aug 01, 2015**