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COMPARATIVE EVALUATION OF WATER SORPTION AND SOLUBILITY OF DIFFERENT RESTORATIVE CEMENTS: AN IN-VITRO STUDY

Clinical Research

Dr. Gayatri Deshmukh*	Post Graduate student, Department of Conservative dentistry and endodontics, V.Y.W.S. Dental College & Hospital. Amravati, Maharashtra, India.* Corresponding Author
Dr. Anant A. Heda	Professor, Department of Conservative dentistry and endodontics, V.Y.W.S Dental College & Hospital. Amravati, Maharashtra, India.
Dr. Narendra U. Manwar	Professor and Head, Department of Conservative dentistry and endodontics, V.Y.W.S. Dental College & Hospital, Amravati, Maharashtra, India.
Dr. Shravan Rathi	Reader, Department of Conservative dentistry and endodontics, V.Y.W.S. Dental College & Hospital, Amravati, Maharashtra, India.
Dr. Neelam Rahul	Senior Lecturer, Department of Conservative dentistry and endodontics, V.Y.W.S. Dental College & Hospital, Amravati, Maharashtra, India.
Dr. Neetish Chavhan	Senior Lecturer, Department of Conservative dentistry and endodontics, V.Y.W.S. Dental College & Hospital, Amravati, Maharashtra, India.

ABSTRACT

Aim: The purpose of this study is to compare and evaluate the water sorption and solubility of five different types of restorative cements, in order to show variations that may reduce their effectiveness.

Materials and methods: Five discs each of five different materials viz. Ketac Molar (3M ESPE), Universal Restorative 2 (GC Gold Label), Ionofil plus (VOCO), High Strength Posterior Restorative 9 (GC Gold Label) and Cention-N (Ivoclar) were prepared. The discs were weighed individually on precision weight scale, dehydrated and weighed again after storing for 1 day at 37oC in 50 ml distilled water. Again, the discs were stored for a week in 50 ml of distilled water at 37oC. All the discs were weighed individually after 7 days, dehydrated and new weights were again recorded. Water solubility of material and its water sorption were obtained from the difference between the intial and the final dry mass of each disc, after 1 day and 7 days of immersion in distilled water. Data was analyzed for significant difference by one-way ANOVA and Tukey's test.

Results: The water sorption values were minimal with Cention-N after 1 day followed by Ketac Molar, Ionofil Plus, Universal Restorative 2 and High Strength Restorative 9; and after 7 days, water sorption values were minimal for High Strength Restorative 9 followed by Ketac Molar, Ionofil Plus, Cention- N and Universal Restorative 2. The solubility values were minimal with Cention-N after 1 day and 7 days followed by Ionofil plus, Ketac molar, High strength restorative 9 and Universal restorative 2.

Conclusion: Among the tested restorative cements, water sorption was minimal with Cention –N after 1 day whereas it was minimal for High Strength Restorative 9 after 7 days. Solubility was minimal for Cention-N after 1 day and 7 days.

KEYWORDS

Water Sorption, Water Solubility, Precision Scale.

INTRODUCTION

Restorative cements are the most important materials in clinical dentistry because of their versatile applications as luting agent, cavity lining, bases and or restorations of teeth. Although they are used in small quantities[1], their usage depends on various properties like strength, solubility, biocompatibility and water sorption[2].

Glass Ionomer Cement (GIC) is known to be most relevant restorative material for Atraumatic Restorative Material due to their biological, physical and chemical properties [3]. It has fluoride releasing properties, adhesion to tooth tissue, high coefficient of thermal expansion, good biocompatibility and high viscosity[4-6]. Longer setting time along with better physico-mechanical properties are seen in such materials[3,7] resulting in higher survival rate of the restoration[8].

Recently, Cention-N, an 'alkasite' group of restorative material is introduced. It is a tooth-coloured, radiopaque, dual cure restorative material used for direct posterior restorations. It releases fluoride, calcium and hydroxide ions. Resin based materials undergo a series of physical changes as a result of the polymerization reaction and the subsequent interaction with the wet oral environment[13].

Restorative cements may degrade when exposed to moisture in oral cavity. Its water sorption and solubility in water may lead to dimensional changes, loss of retention, staining, breaking in margin contours, degradation and less biocompatibility[9]. Because of all these, giving consideration to water sorption and solubility of these restorative materials is of clinical importance.

In the present study, five different types of restorative cements viz., Ketac Molar (3M ESPE), Universal Restorative 2 (GC Gold Label), Ionofil plus (VOCO), High Strength Posterior Restorative 9 (GC Gold Label) and Cention-N (Ivoclar) are used to compare and evaluate the water sorption and solubility properties. Nowadays, these materials are widely used in Atraumatic Restorative Treatment (ART). ART is a low risk economical procedure. We can conserve the tooth tissue and reduce the chance for further decay by manually excavating the caries and restoring the cavity[10].

Ketac molar (3M ESPE) is fluoride releasing packable material offering high strength and excellent handling characteristics[10]. Universal Restorative 2 (GC Gold Label) is a self-cured glass ionomer restorative material featuring high resistance to water[11]. Ionofil Plus (VOCO), having good esthetics, available in three shades with spreadable consistency, good marginal adaptation, continuous fluoride release and improved Glass Ionomer technology[12]. High Strength Posterior Restorative 9 (GC Gold Label) is easy to use, handle and fluoride releasing alternative to expensive compomers and composites and in many cases amalgam[11]. Cention-N (Ivoclar) is a recently introduced posterior load bearing restoration from Alkasite group which offers tooth colored esthetics with high flexural strength[13]. In clinical conditions, all these restorative materials should be biocompatible and should have low water sorption and solubility values.

So, the aim of the present study is to compare and evaluate water sorption and water solubility between these restorative cements.

MATERIALS AND METHODS

The ADA specification #8 (Zinc phosphate cement solubility) was adapted with few alterations to design the methodology used in this study. Distilled water was used as storage media as the ADA

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specification #8 suggests, and the storage time was 7 days.

The following restorative materials were utilized in the current study:
Group 1: Ketac Molar (3M ESPE)
Group 2: Universal Restorative 2 (GC Gold Label)
Group 3: Ionofil plus (VOCO)
Group 4: High Strength Posterior Restorative 9 (GC Gold Label) and
Group 5: Cention- N (Ivoclar)

The manufacturers' instructions were followed for manipulation of the cements respectively. 5 discs (20mm diameter x 1.5mm thickness) of each material were fabricated using 1.5 mm thickness acrylic ring matrix with central cavity of 20 mm diameter (Figure1). The cavities in the ring matrix were filled with cement covered with a Mylar strip and glass plate, which were maintained under finger pressure until complete setting of material (Figure 2). Distilled water was used for immersing the disc shaped specimen and stored at 37°C in incubator.

After 1 day the specimens were weighed on precision scale (Contech Company CB series) (Figure 3), dehydrated with absorbent paper and then kept in hot air oven at 37°C for 1 hour for drying and weighed again.

The discs were immersed and stored in separate beakers containing 50 ml distilled water (Figure 4) at 37°C for 7 days in incubator (Figure 5), which were weighed and dehydrated again as mentioned above and subjected to new weighing.

Water solubility was obtained from difference between intial and final drying mass of each disc, excluding mass of ring.

Water sorption was recorded from difference between wet and dry mass of each disc and from another weight after 7 days immersion in water.

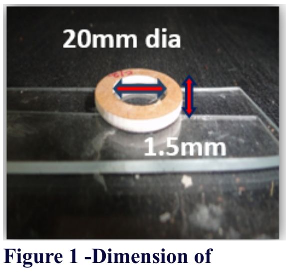


Figure 1 -Dimension of specimen

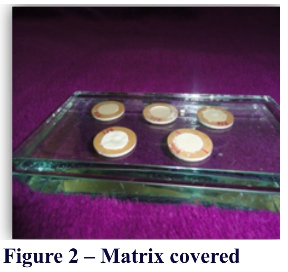


Figure 2 – Matrix covered with glass plate

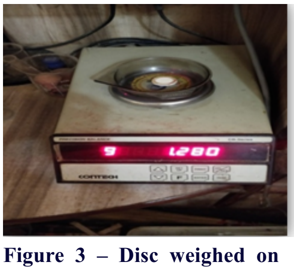


Figure 3 – Disc weighed on precision scale

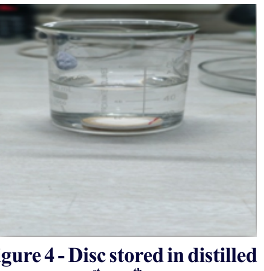


Figure 4 - Disc stored in distilled water from 1st to 7th day.

Figure 5 – Disc stored in incubator.

RESULTS

The first and seventh day readings for both water sorption and solubility were taken and they were subjected to statistical analysis.
On first day, Cention-N showed lowest water sorption and solubility values followed by Universal Restorative 2, High strength restorative 9 and Ketac Molar respectively. Ionofil plus showed highest water sorption and solubility values as shown in table 1.

Table 1: Sorption and Solubility values for the materials evaluated (first day)

Sr. no.	Cement	Water sorption	Water solubility
1	Ketac Molar	12.69 %	12.36 %
2	Universal Restorative 2	8.43 %	8.43 %
3	Ionofil Plus	14.57 %	14.57 %
4	High Strength Posterior Restorative 9	11.82 %	11.82 %
5	Cention-N	7.04 %	7.35 %

On seventh day, High Strength Posterior Restorative 9 showed lowest water sorption value followed by Ketac Molar, Ionofil plus and Cention-N respectively. Universal Restorative 2 showed highest water sorption values. In case of solubility Cention-N showed lowest solubility, after water immersion for 1 week followed by Universal Restorative 2, Ketac Molar, Ionofil Plus respectively. High Strength Posterior Restorative 9 showed highest water solubility values as shown in table 2.

Table 2: Sorption and solubility values for the materials evaluated (seventh day)

Sr. no.	Cement	Water sorption	Water solubility
1	Ketac Molar	2.520 %	5.703 %
2	Universal Restorative 2	5.760 %	1.976 %
3	Ionofil plus	2.927 %	6.041 %
4	High Strength Posterior Restorative 9	1.608 %	6.986 %
5	Cention-N	5.242 %	0.376 %

STATISTICALANALYSIS

The water sorption and solubility values obtained for each material were analyzed statistically by one way ANOVA and Tukey's test at 5% significance level.

Table 3: ANOVA test for water sorption and solubility values (where WA – Sorption value and WS – Solubility value).

		Sum of Squares	df	Mean Square	F	Sig.
WA1	Between Groups	.081	4	.020	1.261	.318
	Within Groups	.321	20	.016		
	Total	.402	24			
WA7	Between Groups	.005	4	.001	17.167	.000
	Within Groups	.001	20	.000		
	Total	.006	24			
WS1	Between Groups	.002	4	.001	1.726	.184
	Within Groups	.006	20	.000		
	Total	.008	24			
WS7	Between Groups	.005	4	.001	29.744	.000
	Within Groups	.001	20	.000		
	Total	.006	24			

WA1- Sorption after 1 day, WA7 – Sorption after 7 days,

WS1- Solubility after 1day, and WS7 – Solubility after 7 days.

Table 4: Significant difference in the water sorption of materials ($p< 0.05$) by the Tukey's test (t),

(I) Material	(J) Material	0-1 day (t)	0-7 day (t)
1.00 Ketac molar	2.00 GC2	.999	0
1.00 Ketac molar	3.00 VOCO Ionofil	.174	0.424
1.00 Ketac molar	4.00 GC 9	.390	0.424
1.00 Ketac molar	5.00 Cention-N	.174	0.002
2.00 GC 2	3.00 VOCO Ionofil	.267	0
2.00 GC 2	4.00 GC 9	.538	0
2.00 GC 2	5.00 Cention-N	.108	0.024
3.00 VOCO Ionofil	4.00 GC 9	.984	0.118
3.00 VOCO Ionofil	5.00 Cention-N	.001	0.01
4.00 GC 9	5.00 Cention-N	.004	0

Table 5: Significant difference in the water solubility of materials ($p< 0.05$) by the Tukey's test (t),

(I) Material	(J) Material	0-1 day (t)	0-7 day (t)
1.00 Ketac molar	2.00 GC2	.799	0.001
1.00 Ketac molar	3.00 VOCO Ionofil	.980	0.639
1.00 Ketac molar	4.00 GC 9	1.000	0.027

1.00 Ketac molar	5.00 Cention-N	.213	0
2.00 GC 2	3.00 VOCO Ionofil	.980	0.003
2.00 GC 2	4.00 GC 9	.799	0
2.00 GC 2	5.00 Cention-N	.799	0.01
3.00 VOCO Ionofil	4.00 GC 9	.980	0.01
3.00 VOCO Ionofil	5.00 Cention-N	.476	0
4.00 GC 9	5.00 Cention-N	.213	0

Figure 6: Mean values of water sorption of each material.

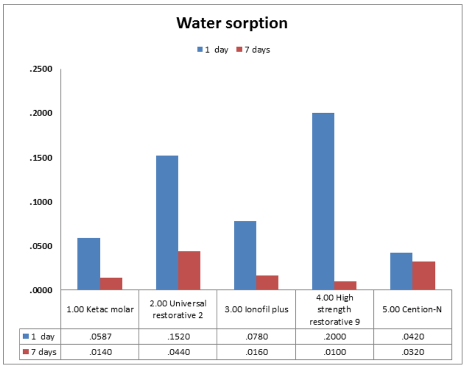
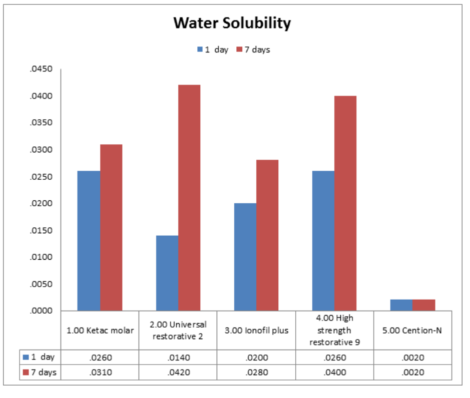


Figure 7: Mean values of water solubility of each material.



DISCUSSION

The water sorption and solubility are of considerable clinical importance in dental restorative materials and cannot be disregarded[14, 15]. The chemical composition of the material plays an exuberant role in its physicochemical properties.

The water sorption measured the actual net gain in weight of a specimen as a result of the entrance of water molecules and exit of monomers and other small molecules[16]. Diffusion mechanisms are a stepwise migration from one site to another according to an atomic point of view, two patterns are known for diffusion of water through polymeric materials[17], (a) The free volumetric theory, in which the water spreads through a micro voids without any correlative relationship to the polar molecules in the material (b) Interaction theory, in which water spreads through material binding consecutively to the hydrophilic groups. When there was a negative association between the diffusion and equilibrium water consumption, the later pattern of diffusion was meant to happen mainly. Nowadays, it is being supposed that both approaches could be correct, each one for a defined individual family or both once[17].

The capacity of a substance to dissolve in other indicated as the concentration of saturated solution of the former in the latter is solubility. When it is tested, no particle is seen in suspension (the solvent remains clear and transparent)[18].

The aim of this study was to clarify essential values for the water sorption and solubility for the evaluation of the quality of each material, which is of important clinical pertinence[1].

The choice for the five different dental cements here evaluated was based on the fact that they are the most commonly used conventional restorative materials in the clinical practice.

According to the ADA's #8 specification water sorption and solubility tests were applied, although with few modifications to meet the objectives of this study[19].

The same hydrolysis of the cement components makes glass ionomer cements more responsive to water erosion[20]; the phenomenon is evidently aggravated in oral environment by presence of various compounds in saliva. GIC is weakened by early exposure to moisture, while dehydration on the other hand causes shrinkage and cracks. So its clinical success depends on early protection from hydration and dehydration; Deniz et al[21] found that, earlier exposures of mixed cement to water may lead to higher levels of solubility, as GIC was highly sensitive to water contact in the first 6 minutes after mixing. According to Warrier et al[22], lack of adequate strength and toughness is one of the main disadvantages of GIC. They are usually weak after setting and are unstable in water, however as the reaction progresses they become stronger and more resistant to moisture.

According to ADA specification # 8, acceptable water sorption and water solubility values are 1.25 % and 0.2 % respectively. In the study of water sorption after 1 day highest mean value was recorded with High Strength Posterior Restorative 9 cement (t- 0.2) and least with Cention-N (t- 0.042); whereas after 7 days, highest mean value was seen with Universal Restorative 2 cement (t- 0.044) and least with High Strength Posterior Restorative 9 cement (t- 0.01). In case of water solubility after 1 day, highest mean value was observed with Ketac Molar and High Strength Posterior Restorative 9 as (t- 0.026) and least value was seen with Cention-N (t- 0.002); whereas after 7 days, highest mean value was seen with Universal Restorative 2 (t- 0.042) and least with Cention- N (t- 0.002).

Universal Restorative 2 showed higher values because of higher levels of calcium fluoride in this cement[23]. Also, Benhameurlain et al [24] stated that, conventional GIC showed greatest sorption and material net loss as compared to other tooth-colored restorative materials. Higher mean values for solubility with High Strength Posterior Restorative 9 cement were recorded in our study. According to Sidhu et al[25], the modified glass ionomer cement has similar or comparable water balance as conventional GIC and, hence, is equally moisture sensitive. The least value for sorption seen in the experiment for High Strength Posterior Restorative 9 cement correlates with acceptable ADA water sorption value (1.25%). The least values of solubility observed with Cention-N correlates with acceptable ADA specification water solubility value (0.2%). The sorption and solubility values were found to depend on the type and content of filler, filler concentration, mean particle size, the coupling agents, the nature of the filler particles, and the type of solvent according to a study by Meşe et al[26]. Cention-N has special patented filler (Isofiller) which is having property of shrinkage stress relieving that minimizes shrinkage forces during polymerization. According to the manufacturer, as the forces between the fillers grow during polymerization this shrinkage stress reliever within Cention-N acts like a spring expander. Moreover, its low volumetric shrinkage and bulk filling of Cention-N, was achieved by the organic/inorganic ratio and the monomer composition of the material. Minimum literature is available regarding polymerization shrinkage and marginal leakage of Cention-N[27].

The values for Ketac molar were lower with sorption and higher with solubility. According to Lima et al (2018)[23] Ketac Molar Easymix was less sensitive to water sorption, which can be described by the large number of carboxylic acid groups in the liquid of such cements. Its composition contains tartaric acid, a dicarboxylic acid with two carboxyl radicals. Hence, empty spaces and water influx into the material is decreased due to a large number of cross linking between the polymer chains[28].

The medium solubility and sorption of Ionofil Plus may be due to higher fluoride content and release by this cement. Minimum literature is available for water solubility and sorption studies for Ionofil Plus[12].

In first twenty four hours, all the materials exhibited highest water sorption, with a stabilization tendency for the materials in 7 days. Glass Ionomer cements as tested by Lima et al[23] for water sorption and solubility contributed comparable results to the present study.

While choosing the restorative material to be used in restorations, especially using the Atraumatic Restorative Treatment Technique, the water sorption and the solubility properties should be considered as they are directly related to lifetime of treatments[26].

For the in vitro tests, chemical structure of the solutions is important because they cannot imitate the complexity of the oral environment. These tests are static solubility tests only because they do not imitate the pH and temperature changes of the oral cavity[29]. The conditions clinically vary from person to person, making it difficult to reproduce a natural environment[30]. However, further in vitro and in vivo studies are required to confirm the water sorption and solubility values of restorative cements.

CONCLUSION-

Within the limitations of the present study, it can be concluded that-

1. Cention-N showed minimum solubility after 1day and 7 days and minimum sorption after 1 day among all the tested materials (viz., Ketac Molar, Universal Restorative 2, Ionofil Plus, High Strength Posterior Restorative 9, and Cention-N).
2. High Strength Posterior Restorative 9 showed minimum sorption after 7 days.
3. Both these materials correlate with ADA specification # 8 values.
4. The highest water sorption rate, for all materials, occurred 1 day after immersion, with stabilization tendency for some materials after 7days.

REFERENCES-

1) Ahmed Ghanim M. Water sorption and solubility of different commercially available dental cements. (An in vitro study). Medical journal of Babylon. 2010; 7(3-4): 410-421.
2) Rajat Khajuria et al. Comparative Evaluation of water sorption and solubility of two different luting dental cements. IOSR Journal. Dec 2017; 16:15-18.
3) Molina GF, Cabral RJ, Frencken JE. The ART approach: clinical aspects reviewed. J Appl Oral Sci. 2009; 17:89-98
4) Markovic DL, Petrovic BB, PericTO. Fluoride content and recharge ability of five glassionomer dental materials. BMC Oral Health. 2008; 28(8), 21.
5) Tyas MJ. Clinical evaluations of glass-ionomer cement restorations. J Appl Oral Sci. 2006; 14:10-13.
6) Van Duinen R. Clinical effects at the glass ionomer/tooth/saliva interfaces. J Dent. 2006; 34(8), 618-619.
7) Yap AUJ, Pek YS, Cheang P. Physico-mechanical properties of a fast-set highly viscous GIC restorative. J Oral Rehabil. Jan 2003; 30(1), 1-8.
8) Bonifacio CC, Bonifácio CC, Kleverlaan CJ, Raggio DP, Werner A, de Carvalho RC, van Amerongen WE. Physical-mechanical properties of glass ionomer cements indicated for atraumatic restorative treatment. Aust Dent J. 2009; 54(3):233-237.
9) Frencken JE, Van't Hof MA, Van Amerongen WE, Holmgren CJ. Effectiveness of single-surface ART restorations in the permanent dentition: a meta-analysis. J Dent Res. 2004; 83(2):120-123.
10) Ketac Molar. Germany: 3M ESPE ; 2004, Manufacturer's User Manual.
11) GC Gold Label. Singapore: GC Corporation 2006 3MESPE, Manufacturer's User Manual.
12) VOCO The Dentalists. Germany: VOCO GmbH; 2019, Manufacturer's User Manual.
13) Ivoclar Vivadent AG. Cention N. Germany. Schaan/ Liechtenstein; 2016, Manufacturer's User Manual.
14) S. Hakan Tuna DDS etal Water Sorption and Solubility of Provisional and Permanent Luting Cements.Sayi:3, Sayfa 2006: 19-24.
15) Keyf F., Tuna S.H., Sen M., Safrany A.Water sorption and solubility of different luting and restorative dental cement. Turk J Med Sci; 2006; 36(1): 47-55.
16) Macorra JC, Praides G. Conventional and adhesive luting cements. Clin Oral Invest 2002; 6: 198-204.
17) Chai J, Takahashi Y, Hisama K, Shimizu H. Water sorption and dimensional stability of three glass fiber reinforced composites. Int J Prosthodont 2004, 17: 195-9.
18) Bellenger V, Verdu J, and Morel E. Structure properties relationships for densely cross linked epoxy-amine system based on epoxide or amine mixtures. J Mater Sci 1989; 24: 63- 68.
19) Ymazaki A., Yasushi H., M. Honda, Y. Nagasawa, Y. Hasegawa, J. Omatsu, T. Yamaga and H. Nakajima: Effect of Water on Shear Strength of Glass Ionomer Cements for Luting. Dental Materials Journal, 2007; 26 5: 708-712.
20) Luciana Fávaro Francisconi, Anderson Pinheiro De Freitas. Water Sorption and Solubility of Different Calcium Hydroxide Cements. J Appl Oral Sci.2009; 17(5): 427-431.
21) Deniz G., Binnaz Y., Mutlu O. and Hasan N. Alkumru: Effect of early water contact on solubility of glass ionomer luting cements. J Prosthet Dent 1998; 80:474-478.
22) Devika Warrier E et al A Review on Temporary Restorative Materials IJPSR. 2016 Jul; 7: 315-319.
23) Lima R et al Water sorption and solubility of glass Ionomer cements indicated for Atraumatic restorative treatment considering the time and the pH of the storage solution. Rev Gauch Odontol. 2018 Jan-Mar; 66(1): 29-34.
24) Benhameurlain M, Qahtani MQ. Water sorption and desorption of different types of direct tooth colored restorative materials. Pakistan Oral & Dental Journal 2010; 30(2):476-480.
25) Sidhu SK. Glass ionomer cement restorative materials: a sticky subject? Aust Dent J 2011 Jun; 56, 23-30.
26) Meşe A, Burrow MF, Tyas MJ. Sorption and solubility of luting cements in different solutions. Dent Mater J 2008 Sep; 27(5):702-709.
27) Popoff DAV, Gonçalves FS, Magalhães CS, Moreira AN, Ferreira RC, Mjör IA. Repair of amalgam restorations with composite resin and bonded amalgam: A microleakage study. Indian J of Dent Res. 2011; 22(6):799-803.
28) Nicholson JW. Chemistry of glass-ionomer cements: a review. Biomaterials.1998; 19: 485-494.
29) Cattani-Lorente MA, Godin C, Meyer JM. Mechanical behavior of glass ionomer cements affected by long–term storage in water. Dent Mater 1994; 10: 37-44.
30) Uno S, Finger WJ, Fritz U. Long-term mechanical characteristics of resin-modified glass ionomer restorative materials. Dental Mater 1996; 12: 64-69.