Original Article

ID: JCDR/2012/3804:2028

Dentistry Section

The Effect of Capsulated Glass Ionomer Cements on the pH of a Lactic Acid Solution: An In-Vitro Study

SRIDEVI KRISHNAMURTHY, JAMINI NARASIMHAN, RANGEETH BOLLAM NAMMALWAR

ABSTRACT

Aim: This study the evaluated interactions of capsulated glass ionomer cements (GIC) with an aqueous lactic acid solution.

Materials and Methods: GIC fuji cap II and GC fuji cap IX were tested and compared to vials containing a lactic acid aqueous solution with no specimen as the control group. 16 specimens of each material were made according to the manufacturer's instructions. The pH of the solution was measured immediately after 24 hours and at the end of the week. The statistical significance in the pH of the storage solution was determined by using one–way ANOVA.

Result: All the materials were able to increase the pH of the lactic acid solution and both the materials were statistically significant.

Conclusion: These findings can be helpful in predicting the performance of these materials under clinical conditions.

Key Words: Glass ionomer cements, Lactic acid, Buffering capacity, pH

INTRODUCTION

Atraumatic treatment (ART) is a dental approach which is based on the removal of carious tissues with hand instruments, followed by the placement of an adhesive restoration [1-4]. Glass ionomer cement is a material which has created a great impact in the world of restorative dentistry. It is a water based restorative material which consists of leachable glass powder and a polyalkenoic acid which react together to form a cement mass [5,6]. It exhibits true adhesion to the tooth structure and it acts as a reservoir of the fluoride ions which are slowly released over a prolonged period of time [7].

Variation in the acid profile and the concentration may relate to caries progression in the hard dental tissues. When sugar is available in the oral environment; microorganisms produce organic acids such as lactate and acetate. Another relevant factor which is involved in the caries progression is related to the low pH which is generated from carbohydrate metabolism that selects the cariogenic species. It was observed that a low pH environment characterized this condition with a lactate dominant acid profile in the active lesions; therefore, the interaction between the lactic acids and the restorative materials should also be considered. Conventional glass ionomer cement represents the oldest category of the glass ionomer cements and it has the disadvantage of inferior mechanical properties [8,9]. To overcome this, newer, more- viscous, aesthetic and reinforced glass ionomer cements were specially developed for their use in the alternative restorative technique (ART). These materials have the ability to neutralize the salivary acid by buffering the lactic acid via the release of chemical ions [10].

The predominant factors which control the stability of the enamel apatite are its pH and the concentrations of calcium, phosphate and fluoride in the surrounding solution. A pH drop of one unit within the pH range of 4 to 7 will result in a 7 fold increase in the solubility of the hydroxyapatite [11]. It has been stated that the release of fluoride and other elements from the dental materials are affected by the changes in pH, especially those of the glass ionomer matrix forming elements like calcium, strontium and aluminum [12].

Considering the above aspects, the present study was undertaken to evaluate the buffering capacity of the newer, high viscous glass ionomer cements and the conventional glass ionomer cement.

MATERIALS AND METHODS

Two restorative grade glass ionomers were employed in this study, namely the GIC Fuji cap II and the GC FUJI IX capsule. 32 cylindrical specimens of dimension (6mm diameter x 3 mm in height) were prepared by mechanical mixing; both the cements were handled according to the manufacturer's instructions. The cements were inserted into previously lubricated, cylindrical, poly tetrafluoroethylene moulds of appropriate size.

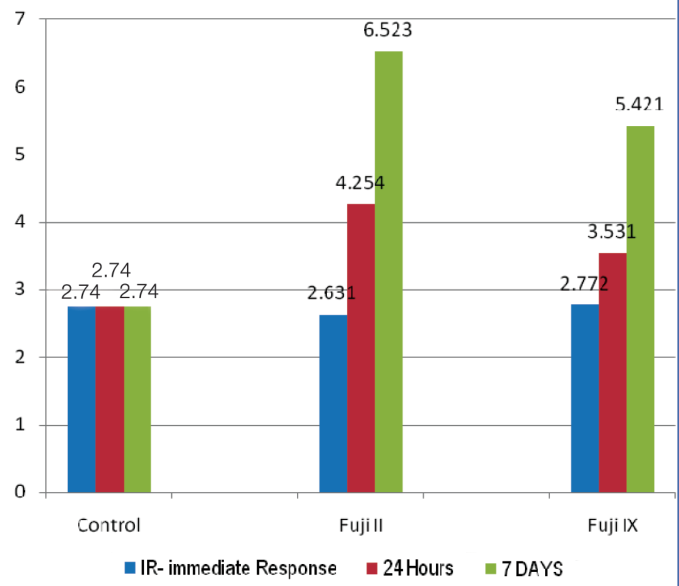
The cements were allowed to be cured for 1 hour in the moulds at 37^0C before being removed and placed in a lactic acid solution (2.0 cm^3, 20 $mmol^{-1}$pH 2.7). The control solutions were stored under identical conditions but those which contained no cement were also prepared. The pH of the cements which were immersed in the lactic acid solution were measured immediately after 24 hours and after a week by using a digital pH meter (Bionics) .The statistical significance in the pH of storage solution was determined by using one way ANOVA.

RESULT

The pH increasing ability was material and time dependent as was the interaction between these variables ($p<0.00$ 1). All the materials increased the pH of the lactic acid storage solution at all the evaluation periods ($P<0.001$). The pH changes of the aqueous lactic acid solution which were recorded over a week were analyzed. [Table/Fig-1], [Table/Fig-2] A greater increase in the lactic acid pH was observed in a week; both the materials were statistically significant.

Groups	IR	SD	24 Hours	SD	7 Days	SD
Control	2.74		2.74		2.74	
Fuji II	2.631	+/- 0.0014	4.254	+/- 0.0028	6.523	+/- 0-0007
Fuji IX	2.772	+/- 0.0035	3.531	+/- 0.0085	5.421	+/- 0.0014
Significance	yes		yes		yes	
p <0.001						

[Table/Fig 1]: Results of the one way ANNOVA analysis of the samples pH showing the alteration in the pH values over a period of time
IR- Immediate Response; SD - Standard Deviation.



[Table/Fig-2]: Graphical representation of the pH changes when compared to the Control Group

DISCUSSION

The anti-cariogenic capacity is a relevant property of GIC and it is thus expected that the interaction of these materials with an acidic environment will lead to an increase in the pH [13-15]. Under the present experimental conditions, all the tested GIC were able to increase the initial pH of the acid lactic solution. These results were in accordance with those of Nicholson, et al [15], who subjected poly acid – modified composite resins to similar experimental conditions and also verified their ability in neutralizing acidic conditions. Studies have reported that the initial pH of the tested solution (2.74) increased almost by 1 unit in 7 days [16] and investigations into the rate of the change of the pH of lactic acid which was exposed to some ART GIC showed similar results as those of the present study [14].

The pH increase of the acid storage solution is attributed to the acid basic setting reaction of the dental cements with salt formation. It is known that cements which are made from lower concentrations of polyacid are weaker that those which are made from higher concentrations of polyacid [16,17]. In the case of each cement, attack at the matrix releases both poly acrylic acid and metal ions. Consequently, the storage solution becomes a mixture of lactic acid and metal lactates, the classic combination that creates a buffer solution. In the present study, the measurements were made after 1 week, the time which was likely to be sufficient for the mixtures to be fully equilibrated.

The acid neutralizing effect which was observed in this study was desirable, since it had a chance to be a mechanism of protection against the secondary carries. Active caries has been shown to have a pH of 4.9, with lactic acids being the principle substance which are responsible for the low pH. Such active caries can be arrested by a modest change of the pH to 5.7. In our experiment, we were able to reach this later pH from a starting value of 2.7 (Lactic acid). This demonstrated that these cements were capable of elevating the pH to the level which could arrest the caries and that in principle, they were able to confer localized protection to the teeth from acid attack. This was further evidence to the fact that the effect which we had been studying was likely to prove their clinical benefits when these materials were used to restore teeth.

CONCLUSION

By varying the proportion of the cement to the storage solution and by increasing the numbers of specimens, we could obtain a significant factor for determining the final pH of the storage solution. Moreover, the final pH which was obtained when 16 specimens were used, was approximately same as that of the arrested caries, even though the initial pH of the lactic acid solution which was employed was much lower at 2.7 than that of the active caries in vivo. This suggested that the buffering effect of these cements was likely to be sufficient to have an important effect when these materials were used clinically.

REFERENCES

[1] Barata TJE, Bresciani E, Mattos MCR, Lauris JRP, Ericson D, Navarro MFdL. Comparasion of two minimally invasive methods on the longevity of glass ionomer cement restorations: short-term results of a pilot study. *Journal of Applied Oral Science*. 2008;16:155-60.
[2] Frencken JE, Songpaisan Y, pHantumvanit P, Pilot T. An atraumatic restorative treatment (ART) technique: evaluation after one year. *Int Dent J*. 1994 Oct;44(5):460-64.
[3] Rahimtoola S, van Amerongen E, Maher R, Groen H. Pain which was related to different ways of minimal intervention in the treatment of small caries lesions. *ASDC J Dent Child*. 2000 Mar-Apr;67(2):123-27, 83.
[4] Wang L, Lopes LG, Bresciani E, Lauris JR, Mondelli RF, Navarro MF. Evaluation of the Class I ART restorations in Brazilian schoolchildren: three-year results. *Spec Care Dentist*. 2004 Jan-Feb;24(1):28-33.
[5] Kudalkar SA, Damle SG. The comparative evaluation of the release profiles of aluminium, fluoride, sodium and strontium by resin modified and conventional glass polyalkenoate cements in neutral and acidic media – an in vitro study. *J Indian Soc Pedod Prev Dent*. 1997 Mar;15(1):1-9.
[6] Yip HK, Lam WT, Smales RJ. Fluoride release, weight loss and erosive wear of modern aesthetic restoratives. *Br Dent J*. 1999 Sep 11;187(5):265-70.
[7] Mount GJ. Glass ionomers: a review of their current status. *Oper Dent*. 1999 Mar-Apr;24(2):115-24.
[8] Hojo S, Komatsu M, Okuda R, Takahashi N, Yamada T. The acid profiles and the pH of carious dentin in active and arrested lesions. *J Dent Res*. 1994 Dec;73(12):1853-57.
[9] Hojo S, Takahashi N, Yamada T. Acid profile in carious dentin. *J Dent Res*. 1991 Mar;70(3):182-86.
[10] Davidson CL. Advances in glass-ionomer cements. *J Appl Oral Sci*. 2006;14 Suppl:3-9.
[11] Baig AA, Fox JL, Young RA, Wang Z, Hsu J, Higuchi WI, et al. Relationships among the carbonated apatite solubility, crystallite size, and the microstrain parameters. *Calcified Tissue International*. 1999;64(5):437-49.
[12] Forss H. The release of fluoride and other elements from light-cured glass ionomers in neutral and acidic conditions. *J Dent Res*. 1993 Aug;72(8):1257-62.
[13] Garcez RM, Buzalaf MA, de Araujo PA. The fluoride release of six restorative materials into water and pH-cycling solutions. *J Appl Oral Sci*. 2007 Oct;15(5):406-11.
[14] Nicholson JW, Aggarwal A, Czarnecka B, Limanowska-Shaw H. The rate of change of the pH of lactic acid which was exposed to glass-ionomer dental cements. *Biomaterials*. 2000 Oct;21(19):1989-93.
[15] Nicholson JW, Czarnecka B, Limanowska-Shaw H. The interaction of glass-ionomer cements which contained vinylphosphonic acid

with water and aqueous lactic acid. J Oral Rehabil. 2003 Feb;30(2): 160-64.
[16] Nomoto R, McCabe JF. A simple acid erosion test for dental water-based cements. *Dent Mater*. 2001 Jan;17(1):53-9.
[17] Nicholson JW, Millar BJ, Czarnecka B, Limanowska-Shaw H. Storage of polyacid-modified resin composites ("compomers") in lactic acid solution. *Dent Mater*. 1999 Nov;15(6):413-i6.

AUTHOR(S):
1. Dr. Sridevi Krishnamurthy
2. Dr. Jamini Narasimhan
3. Dr. Rangeeth Bollam Nammalwar

PARTICULARS OF CONTRIBUTORS:
1. (Corresponding Author), Senior Lecturer, Department of Conservative Dentistry and Endodontics, Thai oogambigai Dental College and Hospital, Chennai, India.
2. Reader, Department of Conservative Dentistry and Endodontics, Indira Gandhi College of Dental Science, Chennai, India.
3. Reader, Department of Pedodontics, Thai Moogambigai Dental College and Hospital, Chennai, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Sridevi Krishnamurthy
17, Vallal Pari Nagar, Mogappair, Chennai – 600050, India.
Phone: +91-9444193541
E-mail: drsridevi_k@yahoo.com

FINANCIAL OR OTHER COMPETING INTERESTS:
None.

Date Of Submission: **Dec 14, 2011**
Date Of Peer Review: **Jan 18, 2012**
Date Of Acceptance: **Feb 02, 2012**
Date Of Publishing: **Apr 15, 2012**