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Orginal Article

COMPARATIVE ANALYSIS OF THE SOLUBILITY OF MODIFIED CONVENTIONAL GLASS IONOMER CEMENT AND RESIN-MODIFIED GLASS IONOMER CEMENT IN ARTIFICIAL SALIVA WITH VARYING PH LEVELS

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ABSTRACT

Objectives: *To determine the solubility of modified conventional glass ionomer cement and resin-modified glass ionomer cement in artificial saliva at varying pH levels.*

Materials and Methods: *Two luting cements were used to fabricate 120 specimens, following ISO standard 4049/2000. The specimens were divided into two groups, Group A (conventional glass ionomer luting cement) and Group B (resin-modified glass ionomer luting cement), each containing 60 specimens, and further sub-divided into three subgroups A3,A7,A9,B3,B7 and B9. Solubility was assessed by measuring weight changes after immersion in artificial saliva with varying pH levels for 28 days. A one-way ANOVA was conducted to statistically assess the differences in mean solubility among the groups, with post hoc Tukey's test applied for multiple comparisons. Additionally, paired t-tests were used to compare results between groups based on the media used.*

Results: *Mean solubility of specimens of subgroup A9 immersed in basic salivary solution showed least solubility among all the groups. The mean solubility of G1 & RMGI luting cement in artificial cement saliva having PH 3.7& 9 respectively.*

Conclusion: *Conventional glass ionomer luting cement with modified powder/liquid ratio is more reliable for luting of fixed prosthesis as it exhibited lowest solubility in basic and acidic conditions.*

Key words: *Solubility, glass-ionomer luting cement, artificial saliva, resin modified glass ionomer luting cement*

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INTRODUCTION

The durability and dimensional accuracy of a fixed prosthesis are essential for ensuring the therapeutic success of the prosthesis[1]. Attachment of indirect restorations to teeth involves using dental luting cement, which is a moldable material used to seal gaps between natural teeth and prosthesis[2]. The structural integrity of luting cements depends upon the water sorption and solubility. Water absorption leads to an increase in weight and solubility through sorption, negatively impacting the cement's mechanical properties including flexural strength, rigidity, and mechanical stability. This can result in dissolution of the material components, which may

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result in failure of the fixed prosthesis[3].

Furthermore, factors such as dimensional changes, decreased retention, material degradation, and discoloration can collectively compromise the aesthetic quality of the restoration[1]. It is also thought that solubility can contribute to recurrent caries, post-operative hypersensitivity, pulpal inflammation, and periodontal disease[4].

Various factors affect the solubility of the luting cements, including their composition, powder-liquid ratio, fluoride ion release, patient's oral hygiene, dentifrice composition, pH of consumed foods/ beverages, and saliva composition and pH[4]. Studies have demonstrated that acidic pH levels significantly increase the solubility[5,6]. Therefore, patients who consume more acidic beverages exhibit higher solute diffusion. This is attributed to decrease in salivary pH, which leads to the hydrolytic breakdown of cements in oral fluids. Prolonged maintenance of saliva at lower pH levels may further exacerbate solubility[5].

Luting cements are available in various forms, ranging from conventional water-based formulations to anhydrous form. Glass ionomer cement (GIC), commonly used luting cement is based on acid-base reaction between polyacrylic acid and aluminosilicate glass. Moisture contamination during setting can affect their performance. Hence, the susceptibility of conventional glass-ionomer materials to both desiccation and salivary contamination presents significant clinical challenge[7]. Resin-modified glass ionomer luting cements (RMGIC), containing polymers of modified polyacrylic acid, have the capability of copolymerization with other resins and participation in the setting reaction. Their water absorption properties are thoroughly documented[8]. Resin-based luting cements represent significant advancement in adhesive luting techniques.

The introduction of new techniques and materials in dentistry is expanding rapidly. Various luting agents are utilized, each with its own set of advantages and disadvantages[9]. Literature review suggests no luting cement meets all requirements. Solubility is a common issue encountered with these materials. Researchers have conducted comparisons of luting agents based on their solubility[10]. Selecting the appropriate cement based on clinical context and oral fluid exposure is critical for restoration longevity. This aids clinicians in informed decision-making and contributes to restoration success[10,11].

This study focuses on comparing the solubility of two types of luting cements: conventional glass ionomer with a low liquid-to-powder ratio and resin-modified glass ionomer in artificial saliva with varying pH levels.

MATERIALS AND METHODS

Commercially available glass ionomer luting cement (Harvard Ionoglas Cem, Harvard Dental, GmbH, Germany.) and resin modified glass ionomer luting cement (Vivaglass CEM PL, Ivoclar Vivadent, AG, Germany.) were used in this study. Specimens were fabricated using stainless steel mold with dimension of 10mm × 2mm[4]. A total of 120 specimens were divided equally into two groups: Group A (GI) and Group B (RMGI). Each group was further divided into subgroups A3, A7, A9, B3, B7, and B9 having 20 specimens each which were soaked in artificial saliva having pH 3, 7 and 9 respectively.

The GI luting cement was mixed with a modified liquid-to-powder ratio, using half the recommended liquid by the manufacturer. The RMGI luting cement was mixed in accordance with the instructions provided by the manufacturer. The mold was placed on top of a glass slide covered with cellulose acetate strips and was slightly overfilled with the mixed material. Another cellulose acetate strip was placed over the material, and a glass slide was used to press the material into the mold. The GI luting cement specimens were allowed to set chemically while the specimens of RMGI luting cement were light cured for 20 seconds on each side using a light curing unit. This process was repeated for all 120 specimens. After the initial setting, each specimen was removed from the mold and examined for porosities or defects with the naked eye under a dental unit light[2].

The artificial salivary solution was prepared using 0.400g NaCl, 0.400g KCl, 0.79g CaCl2H2O, 0.69g NaH2Po4, 0.005g Na2S.9H2O, and 1.0g urea per 1000 ml of distilled water. The pH of the saliva was adjusted to 3, 7, and 9 using NaOH and HCl, and the volume of the solution was adjusted to one liter[12].

After meeting the selection criteria, all specimens were placed in a desiccator containing silica gel at 37°C for 24 hours. Following this, the specimens were left at room temperature for one hour to achieve a consistent mass (M1). They were then weighed on a precision scale (SARTORIUS, Germany), and the volume of each specimen was estimated before being placed in separate glass vessels with 20 ml of artificial saliva adjusted to pH 3, 7, and 9. The specimens were stored in an incubator (Laboratory Electro thermal Thermostatic Incubator, China) for 28 days at 37°C. After the storage period, the specimens were removed from the liquid, blotted dry with absorbent paper to remove surface moisture, desiccated as mass M1, and weighed again for final mass (M2)[2].

Solubility was determined using formula

Water solubility= M1-M2/V

Statistical analysis was performed using IBM SPSS Statistics 22. One-way ANOVA was used to assess difference in solubility between the groups Post-hoc Tukey test was used for multiple comparisons. Paired samples t-test was used to compare results between groups based on media at a significance level of $p \leq 0.05$.

RESULT

The mean solubility of GI and RMGI luting cements in artificial saliva having pH 3, 7 and 9 respectively is shown in figure 1

One-way analysis of variance (ANOVA) revealed that the collected data are statistically significant, with values indicating significance below 0.05. Means in homogeneous subsets determined through Tukey's (HSD) test indicated that sub group A 9 (0.0009 ± 0.003) immersed in artificial saliva having pH 9 showed least solubility , followed by group A7 (0.2435± 0.018) immersed in artificial saliva having pH 7 and A3 (0.4895 ± 0.035) immersed in artificial saliva having pH3. There was no significant difference found between groups B3 (1.002 ± 0.013), B7 (1.005 ± 0.015) and B9 (1.003 ± 0.011).

Paired T-test was applied for comparison of the groups against each media. The results of paired t-test are given in table no.1

DISCUSSION

The solubility of luting materials is critically important in clinical settings as it affects the rate of degradation, biocompatibility, and marginal integrity, ultimately reducing the longevity and survival of restorations[13]. Water sorption and solubility in cements cause dimensional changes that can lead to restoration failure. Therefore, luting cements should possess high strength and low solubility[14].

This study aimed to determine essential values for assessing the quality of materials resistant to dissolution in artificial saliva at different pH levels (3, 7, and 9). These findings are crucial for clinical applications. The selection of GI and RMGI luting cements was based on their widespread use as luting materials in clinical practice. The results indicate that RMGI luting cement exhibited higher mean solubility values, while GI luting cement exhibited lowest values.

Glass ionomer cements are prone to water erosion, potentially due to the hydrolysis of their components in an aqueous medium. The clinical success of these cements depends upon early protection from

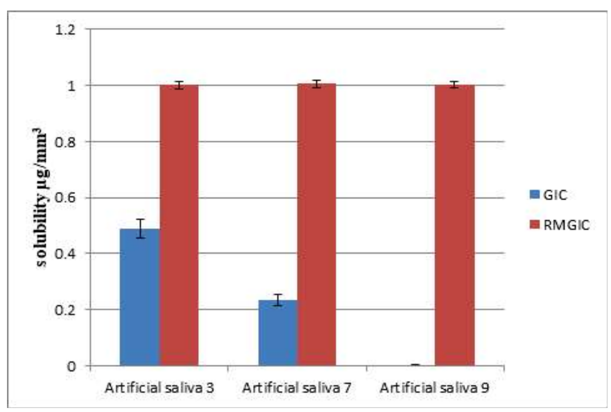

Fig 1: Mean Solubility of GIC and RMGIC in artificial media having different pH

Table 1: The paired samples t-test results for comparing subgroups within groups A and B.

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
A3-B3	-.51250	.03782	.00846	-.53020	-.49480	-60.604	19	.000
A7-B7	-.76200	.02285	-.00511	-.77269	-.75131	-149.139	19	.000
A9-B9	-1.00210	.01187	.00265	-1.00765	-.99655	-377.638	19	.000

both hydration and dehydration. Early exposure to moisture weakens them, while desiccation can cause shrinkage and cracking. These cements are particularly sensitive to water contact within the first 6 minutes after mixing[15]. Deniz et al. demonstrated that higher solubility levels in GI luting cements were linked to early exposure to moisture. Furthermore, GI luting cements were found to be significantly harder than RMGI luting cements, likely due to a solid silicate phase forming around the non-reactive glasses, contributing to hardening[16].

In this study, the P/L ratio of conventional GI luting cement was adjusted to half the liquid recommended by the manufacturer. The solubility of this modified cement was compared to that of RMGI luting cement in artificial saliva having pH levels of 3, 7, and 9. The results showed that GI luting cement had the lowest solubility in all three media compared to RMGI luting cement. Similarly, Yanikoglu et al. found statistically significant differences in solubility when using artificial saliva at different pH levels, with cements being more soluble in acidic conditions and more stable in basic conditions at pH 7. Zinc phosphate cement had the highest solubility, followed by zinc polycarboxylate, with glass ionomer cement having the least solubility[17].

Yosi et al. found that RMGIC (resin modified glass ionomer cement) has higher solubility than ERMGIC (enhanced resin modified glass ionomer cement) due to the hydrophilic characteristics of the HEMA (hydroxyl ethyl methacrylate) monomer, which allows liquids to dissolve unpolymerized monomers within the material. Higher degrees of conversion correlate with lower solubility, explaining why RMGIC, with a lower degree of conversion than ERMGIC, is more soluble[5].

In a study by Nashandar Asli, GIC and RMGIC exhibited lower solubility than zinc phosphate cement, with RMGIC showing the least solubility. This contrasts with our study, where GIC showed the lowest solubility compared to RMGIC. The higher solubility of RMGIC may be due to its chemical structure, which includes polyacrylic acid and HEMA, leading to a dual setting reaction and increased hydrophilicity. This makes RMGIC less stable hydrolytically compared to conventional glass ionomer cements. Additionally, differences in filler content affect solubility, with higher filler content typically decreasing the solubility. The findings of our study were consistent with these observations, particularly given the modified liquid-to-powder ratio used in our study[15,18].

CONCLUSION

The findings of our study lead to the conclusion that the modified GI luting cement exhibits lower solubility and greater reliability when used as a luting agent.

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CONFLICT OF INTEREST
Authors declare no conflict of interest.
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AUTHORS' CONTRIBUTION

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Conception or Design:	RZ, MS, MN, MY, TAK, RZ
Acquisition, Analysis or Interpretation of Data:	RZ, MS, MN, MY, TAK, RZ
Manuscript Writing & Approval:	RZ, MS, MN, MY, TAK, RZ

All the authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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