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EFFECT OF TIME ON FLUORIDE RELEASE FROM RIVA LIGHT CURE AND CENTION FORTE

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ABSTRACT

Background: Dental restorative materials used for pedodontic patients play a critical role in clinical success, influenced by their water absorption and solubility characteristics in the oral environment.

Aims: This study aimed to evaluate and compare the fluoride release of Riva Light Cure and Cention Forte after four different time periods.

Materials and Methods: For fluoride release, ion-specific electrodes measured cumulative release at 24 hours, 1 week, 4 weeks, and 6 weeks. Forty samples were fabricated. Statistical analyses were performed using Welch's t-test to compare the means of Riva Light Cure and Cention Forte at each time point and a post-hoc Tukey's test. The effect size was calculated using Cohen's d. Additionally, 95% confidence intervals were determined for the mean differences between the groups to evaluate the precision of the estimates.

Results: Fluoride release analysis showed a statistically significant difference. Riva Light Cure exhibited the highest cumulative fluoride release (39.448 ± 2.077) followed by Cention forte (27.731±0.894). Cention Forte displayed an initial burst effect with high fluoride release at 24 hours. while Riva Light Cure exhibited the highest cumulative fluoride release at 6 weeks. The effect size (Cohen's d = 7.33) confirmed a very large difference, and the 95% confidence interval (10.10–13.33) supported the reliability of the findings

Conclusion: These findings aid clinicians in selecting suitable restorative materials based on fluoride dynamics, water absorption, and solubility to optimize oral health outcomes.

KEYWORDS: Fluoride release, Riva Light Cure, solubility, dental restorative materials.

INTRODUCTION

Fluoride, renowned for its anti-cariogenic properties, stands as a cornerstone in preventive dentistry. Its mechanisms of action, including the replacement of hydroxyl ions in hydroxyapatite crystals and the formation of acid-resistant fluorapatite, underscore its pivotal role in caries prevention [1, 2]. Moreover, fluoride influences bacterial metabolism and disrupts biofilm formation near restorations, further contributing to its efficacy in combating dental caries [3,4]. Glass ionomer cements (GICs) represent a prominent class of fluoride-containing restorative materials, lauded for their capacity to release fluoride ions. This property not only hinders enamel demineralization but also fosters remineralization and curtails plaque growth [5,6].

Despite their notable anti-cariogenic benefits, traditional GICs have faltered as long-term restorative materials due to inherent mechanical deficiencies, including low compressive strength and wear resistance [2-7]. In response to these limitations, various strategies have been devised to enhance the mechanical resilience of fluoride-releasing materials. Resin-modified glass ionomer cements (RM-GICs) and glass hybrids (GHs) have emerged as promising alternatives, leveraging the benefits of both GICs and resin-based composites [7,9]. RM-GICs, augmented with water-soluble methacrylate monomers, aim to bolster mechanical properties, albeit with limited success. Conversely, GHs, fortified with fluoroaluminosilicate glass fillers and high-molecular-weight polyacrylic acid molecules, exhibit improved physical characteristics [10-14].

The quest for optimized fluoride-releasing materials extends beyond GICs and their derivatives. Alkasite-type resin composites and modified resin-based composites now incorporate fluoride additives to augment their anti-cariogenic potential [5, 9]. These advancements underscore the importance of fluoride release in contemporary restorative dentistry [4, 11].

However, the integrity of these materials can be compromised by environmental factors such as moisture and other liquids, which impact their longevity and performance. Excessive fluid absorption can harm the resin's integrity by reducing its properties, thus affecting how long the restoration lasts [12]. These effects may include annealing, chemical conversions like oxidation and hydrolysis, and alterations in volume such as expansion [6]. Extended exposure to water might lead to color changes due to water absorption and the resin's hydrophilic nature [15]. Additionally, the size and distribution of filler particles can contribute to staining in resin composites [16].

The longevity of restorations is influenced by their ability to withstand environmental challenges. Factors such as matrix hydrophilicity, conversion levels, and solvent properties affect susceptibility to absorption and dissolution rates. Research has shown that the length of immersion affects absorption, dissolution, and pH levels of the liquid. Scientists commonly use the ISO 4049 method to evaluate how dental restorations absorb water and dissolve [12-16].

Materials and Methods

Materials

The material used in the study are the following:

1. GIC RIVA (SDI, Australia)
2. CENTION Forte® HT (GC Corp., Japan)

Specimen fabrication process

For the assessment of fluoride release, 40 samples were fabricated (20 for each group). The preparation followed meticulous adherence to manufacturer instructions to ensure consistency and accuracy in the fabrication process. Custom molds measuring 8mm in diameter and 3mm in height (For fluoride tests), designed using AutoCAD® software and crafted from polytetrafluoroethylene (PTFE), were employed to shape the materials into disc-shaped samples. These molds, supported by cement slides covered with cellulose acetate strips, provided a stable platform for sample formation. Each material was mixed according to the manufacturer's specifications and introduced into the custom mold. The mixed material was then dispensed into the mold, and any excess was carefully removed to maintain uniformity. The molds were then subjected to appropriate curing methods specific to each material, such as light-curing or self-curing, as directed by the manufacturer. The groupings were as follows:

1. **(GIC Riva):** The mixed material was encapsulated and mixed using an amalgamator before being dispensed into the mold and light-cured.
2. **(CENTION Forte®):** These materials were prepared using their respective mixing and curing protocols.

After fabrication, all specimens were meticulously polished with silicon carbide paper to ensure smooth surfaces and uniformity across samples, minimizing potential variations during subsequent testing.

Testing Procedures

Each prepared sample underwent sequential immersion in distilled water and acidulated phosphate fluoride (APF) gel to assess fluoride release over time. At four designated intervals (24 hours, 1 week, 4 weeks, and 6 weeks), the samples were immersed in distilled water to measure fluoride release. Subsequently, each sample was immersed in 2 ml of 1.23% APF gel for 4 minutes to simulate clinical conditions. Following APF gel exposure, the samples were once again immersed in distilled water and subjected to the same time intervals for further fluoride release measurements. Fluoride release was quantified using a fluoride ion-selective electrode connected to a digital ion analyzer, with readings converted to ppm fluoride concentration. This allowed for the assessment of cumulative fluoride release dynamics over the specified time intervals for each material group (Figure 1).

Figure 1 *(Ion selective electrode (ISE).)*

Statistical Analysis

The Tukey HSD analysis was performed to find significant differences between the means of different groups. This statistical test, performed after a one-way analysis of variance (ANOVA), identifies which means differ substantially from one another by analyzing the differences in means for all possible group pairs and adjusting the p-value to limit the probability of false positive results (Type I error).

RESULTS

Fluoride Release and Accumulative Fluoride Release

The descriptive statistics, including the minimum, maximum, mean, and standard deviation (SD) of fluoride release for the groups (Riva LC and Cention Forte) over different time intervals (1-day, 1-week, 4-weeks, 6-weeks) are shown in Table 3-1 and illustrated in Figure 4.

Table 3-1 *(Descriptive statistics of fluoride release for groups in the intervals (1-day,1w, 4w, 6w).)*

		1-day	1 week	4 weeks	6 weeks
Riva (LC)	Minimum	2.109	5.301	17.537	10.260
	Maximum	3.496	6.403	20.892	12.745
	Mean	2.490	5.911	19.359	11.689
	±SD	0.432	0.446	1.109	0.922
Cention Forte	Minimum	4.215	5.723	10.773	4.162
	Maximum	5.983	6.582	12.842	5.983
	Mean	4.993	6.171	11.754	4.813
	±SD	0.668	0.325	0.803	0.638

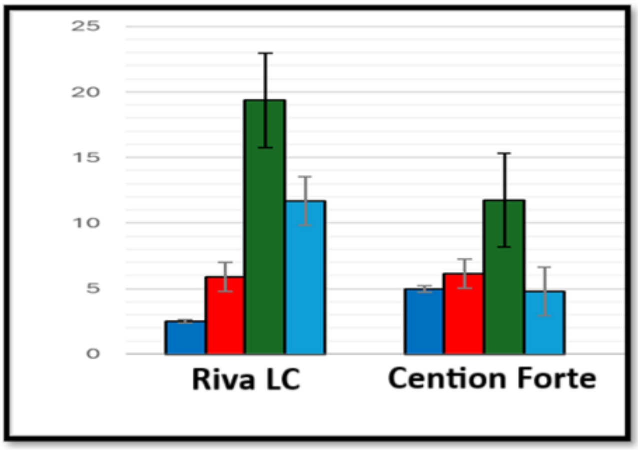

Figure 4 *(fluoride release for the groups in the intervals (1-day,1w, 4w, 6w).)*

Independent T tests between Riva and Cention forte revealed significant differences between all time periods except in one week as in Table 3.2.

Table 3.2 *(Independent t-test & Cohen's d (Effect Size).)*

Time Point	Riva (LC) Mean ± SD	Cention Forte Mean ± SD	t-value	p-value	Cohen's d
1-day	2.490 ± 0.432	4.993 ± 0.668	-9.95	**0.000**	**4.45**

Time Point	Riva (LC) Mean ± SD	Cention Forte Mean ± SD	t-value	p-value	Cohen's d
1 week	5.911 ± 0.446	6.171 ± 0.325	-1.49	0.155	0.67
4 weeks	19.359 ± 1.109	11.754 ± 0.803	17.56	**0.000**	**7.86**
6 weeks	11.689 ± 0.922	4.813 ± 0.638	19.39	**0.000**	**8.67**

A one-way Anova revealed significant differences among the tested groups as in Table 3.3.

Table 3.3 *(ANOVA (One-Way) for Each Material.)*

Material	F-value	p-value
Riva (LC)	1372.81	**0.000**
Cention Forte	294.03	**0.000**

The results in Table indicate that both materials experience statistically significant changes over time, with Riva (LC) showing a stronger trend.

Table 3.4 *(Tukey's HSD (Post-Hoc) and Regression Analysis for Riva (LC) and Cention Forte.)*

Material	Comparison	Mean Difference	p-value	Regression Coefficient	Standard Error	t-value	p-value
Riva (LC)	1-day vs. 1 week	-3.421	0.0001	**Intercept:** 2.890	0.154	18.77	0.0000
	1-day vs. 4 weeks	-16.869	0.0000	**Time:** 0.689	0.035	19.61	0.0000
	1-day vs. 6 weeks	-9.199	0.0000				
	1 week vs. 4 weeks	-13.448	0.0000				
	1 week vs. 6 weeks	-5.778	0.0000				
	4 weeks vs. 6 weeks	7.670	0.0000				
Cention Forte	1-day vs. 1 week	-1.178	0.059	**Intercept:** 3.501	0.117	29.91	0.0000

Material	Comparison	Mean Difference	p-value	Regression Coefficient	Standard Error	t-value	p-value
	1-day vs. 4 weeks	-6.761	0.0000	**Time:** 0.512	0.021	24.38	0.0000
	1-day vs. 6 weeks	-1.820	0.045				
	1 week vs. 4 weeks	-5.583	0.0000				
	1 week vs. 6 weeks	-0.642	0.223				
	4 weeks vs. 6 weeks	4.942	0.0000				

The accumulative fluoride release descriptive statistics for groups are shown in Table 3-5 and illustrated in Figure 5. Riva (LC) showed the highest accumulative fluoride release, followed by Cention Forte.

Table 3-5 *(Descriptive Statistics of Accumulative Fluoride Release.)*

Groups	Minimum	Maximum	Mean	±SD
Riva (LC)	35.937	42.136	39.448	2.077
Cention Forte	26.510	29.019	27.731	0.894

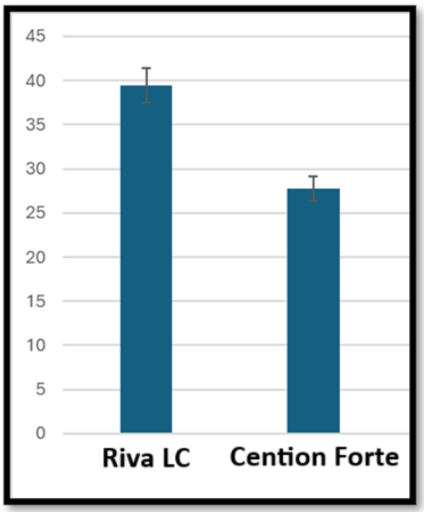

Figure 5 *(bar chart of accumulative fluoride release for all groups.)*

Significant difference between Riva (LC) and Cention Forte, with Riva (LC) performing significantly better. The effect size supports the practical significance of the difference, and the confidence interval reinforces the reliability of this result (Table 3.6).

***Table 3.5** (This table presents the results of the statistical analysis comparing the performance of Riva (LC) and Cention Forte in terms of their descriptive statistics, t-test comparison, effect size, and confidence intervals.)*

Group	Minimum	Maximum	Mean	Standard Deviation (±SD)	t-value	p-value	Significance	Effect Size (Cohen's d)	95% Confidence Interval (Lower Bound)	95% Confidence Interval (Upper Bound)
Riva (LC)	35.937	42.136	39.448	2.077	16.39	0.000	Significant ($p < 0.05$)	7.33	10.10	13.33
Cention Forte	26.510	29.019	27.731	0.894						

DISCUSSION

Fluoride release from dental restorative materials is crucial for preventing dental caries and promoting oral health. Various studies have investigated the fluoride release properties of different materials used in dental restoration, yielding varying results due to differences in methodology, specimen size, storage conditions, and measurement techniques. Understanding the factors influencing fluoride release is essential for selecting materials that balance fluoride release with mechanical and physical properties [17].

This study measured fluoride release using ion-specific electrodes connected to ion analyzers at different intervals (24 hours, 1 week, 4 weeks, and 6 weeks) to assess the long-term capabilities of the materials. Deionized water was chosen as the immersion solution due to its lack of minerals or organic molecules that could influence results and its efficacy in releasing fluoride compared to artificial saliva. This comprehensive evaluation allowed for a thorough understanding of how fluoride release evolve over time and their potential impact on oral health outcomes.

The study evaluated fluoride release for two dental restorative materials: Riva Light Cure and Cention Forte. Riva Light Cure is a resin-modified glass ionomer cement (RMGIC) composed of glass particles, polyalkenoic acid copolymers, and resin monomers such as hydroxyethyl methacrylate (HEMA). Cention Forte is a glass hybrid restorative material consisting of a unique blend of resin-modified glass ionomer (RMGIC) and a high-viscosity glass ionomer.

The results showed statistically significant differences in fluoride release among all groups and intervals ($p < 0.05$). Riva Light Cure recorded the highest cumulative fluoride release. Riva Light Cure exhibited the highest cumulative fluoride release at 6 weeks, supported by previous studies. The dual-setting mechanism of Riva Light Cure, involving an acid-base reaction and light-cure polymerization, sustains the acid-base reaction even after polymerization, leading to prolonged fluoride release over time [13]. Additionally, the high-water sorption of Riva Light Cure promotes acid-neutralization reactions, facilitating the release of fluoride ions from the Fluor aluminosilicate glass present in the material [14-20].

Fluoride release from Riva Light Cure increased gradually and peaked at 4 weeks, in agreement with studies by Neelakantan et al. (2011) [14] and Ibrahim et al. (2020) [15], which demonstrated that the 2-hydroxyethyl methacrylate (HEMA) in RMGIs gradually absorbs water required for fluoride ion diffusion, resulting in gradual fluoride release over time. However, other studies have shown different patterns, with a high initial release followed by a dramatic fall [24]. These variations may be caused by several factors, including the amount of fluoride present in the set materials, the size and composition of the inorganic filler, the duration of the curing process, and the porosity of the inner material [15,22].

Cention Forte recorded the highest fluoride release at the earlier stage (after 24 hours), with a statistically significant difference from all other groups ($p < 0.05$). This can be attributed to its glass hybrid composition, including a nano-filled coating and high-viscosity glass ionomer [24]. The early "burst effect," characterized by the release of large amounts of fluoride in the first 24 hours, is a well-known phenomenon in glass ionomers 18. This effect helps neutralize bacteria and encourages dentine remineralization [25]. The substitution of Sr^{2+} ions for Ca^{2+} ions in glass hybrid technology increases fluoride release since the strontium fluoride complex dissolves more quickly than the calcium fluoride complex [26].

Many studies in the literature have found that the high initial fluoride emission is caused by the "burst effect," in which the material's surface melts, and fluoride is rapidly released when the glass ionomer is exposed to a solution [27]. It is thought that the solubility of the glass powder influences the ultimate setting. These features may account for the high solubility of glass ionomer materials in deionized water [28].

CONCLUSIONS

This study highlights the importance of selecting appropriate restorative materials based on their fluoride release properties to enhance oral health outcomes. Proper selection and understanding of these materials can lead to improved dental restoration success and better oral health.

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