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Comparative evaluation of fluoride release among four commercially available dental restorative materials: An In-Vitro study

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Abstract

INTRODUCTION. Several fluoride-containing dental restoratives are currently available, including glass ionomers (GIC), resin-modified glass ionomer cement (RMGIC), polyacid-modified composite resins (compomers), composites, and amalgams. The fluoride release capabilities of these materials differ due to their matrices and setting mechanisms, which in turn influence their antibacterial and cariostatic properties. Glass ionomer cements are particularly favored for their chemical bonding and fluoride release. However, their limitations include water sensitivity and reduced wear resistance, leading to the development of resin-modified glass ionomers. These materials aim to improve moisture sensitivity and mechanical strength while still providing fluoride release. Despite extensive research on fluoride release, comparative studies involving other fluoride-releasing materials are limited.

AIM. This study aims to evaluate the fluoride release of two glass ionomer cements, a compomer, and a composite resin, and to assess the impact of topical fluorides on their fluoride-releasing abilities.

MATERIALS AND METHODS. The present in-vitro comparative study was conducted at the College of Dental Sciences, Davangere, Karnataka. Four restorative materials were evaluated over 42 days: Conventional GIIC (GC Fuji II), RMGIC (Vitremer, 3M), Compomer (Dyract AP, Dentsply), and Composite (Tetric N Ceram, Vivadent). Specimens were prepared in disc-shaped molds, immersed in deionized water, and fluoride levels measured using a fluoride ion-selective electrode at various intervals.

RESULTS. The study revealed distinct fluoride release patterns among the materials. Group I demonstrated the highest fluoride release on Day 1, significantly surpassing Groups II, III, and IV ($p < 0.001$). While Groups I and II showed a pronounced decrease in fluoride release by Day 2, all groups exhibited a consistent decline over time, with notable intergroup differences.

CONCLUSIONS. The fluoride release characteristics of the evaluated restorative materials varied significantly, emphasizing the importance of material selection based on their fluoride-releasing capabilities to enhance dental health.

Keywords: fluoride release, dental restoratives, glass ionomer cement, resin-modified glass ionomer, compomer, composite resin

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Сравнительная оценка высвобождения фтора четырьмя коммерчески доступными стоматологическими реставрационными материалами: исследование In Vitro

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Резюме

ВВЕДЕНИЕ. В настоящее время доступно несколько фторсодержащих реставрационных материалов для зубов, включая стеклоиономеры (GIC), стеклоиономерный цемент, модифицированный смолой (RMGIC), композитные смолы, модифицированные поликислотами (компомеры), композиты и амальгамы. Способность этих материалов выделять фтор различается в зависимости от их матрицы и механизмов схватывания, что, в свою очередь, влияет на их антибактериальные и кариостатические свойства. Стеклоиономерные цементы особенно ценятся за их химическое связывание и выделение фтора. Однако к их недостаткам относятся чувствительность к воде и пониженная износостойкость, что привело к разработке стеклоиономеров, модифицированных смолами. Целью этих материалов является повышение чувствительности к влаге и механической прочности при одновременном выделении фтора. Несмотря на обширные исследования по выделению фтора, сравнительные исследования с использованием других материалов, выделяющих фтор, ограничены.

ЦЕЛЬ ИССЛЕДОВАНИЯ – оценить выделение фтора двумя стеклоиономерными цементами, компомером и композитной смолой, а также оценить влияние местных фторидов на их способность выделять фтор.

МАТЕРИАЛЫ И МЕТОДЫ. Настоящее сравнительное исследование in vitro было проведено в Колледже стоматологических наук в Давангере, штат Карнатака. В течение 42 дней оценивались четыре реставрационных материала: обычный GIIC (GC Fuji II), RMGIC (Vitremer, 3M), компомер (Dyract AP, Dentsply) и композит (Tetric N Ceram, Vivadent). Образцы готовили в дискообразных формах, погружали в деионизированную воду и измеряли уровень фторида с помощью фторидного ионоселективного электрода с различными интервалами.

РЕЗУЛЬТАТЫ. Исследование выявило различные закономерности выделения фтора из различных материалов. Группа I продемонстрировала наибольшее выделение фтора на 1-й день, значительно превзойдя группы II, III и IV ($p < 0,001$). В то время как в группах I и II наблюдалось выраженное снижение выделения фтора ко второму дню, во всех группах наблюдалось постоянное снижение с течением времени, с заметными межгрупповыми различиями.

ВЫВОДЫ. Характеристики выделения фтора у оцениваемых реставрационных материалов значительно различались, что подчеркивает важность выбора материалов, основанного на их способности выделять фтор, для улучшения здоровья зубов.

Ключевые слова: выделение фтора, зубные реставраторы, стеклоиономерный цемент, стеклоиономер, модифицированный смолой, компомер, композитная смола

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INTRODUCTION

Several fluoride-containing dental restoratives are available today, including glass ionomers, resin-modified glass ionomer cement, polyacid-modified composite resins (compomers), composites, and amalgams. These products differ in their fluoride release capabilities due to their varied matrices and setting mechanisms. Generally, the antibacterial and cariostatic properties of these materials are linked to the amount of fluoride they release [1].

Glass ionomer cements are favored in dentistry for their chemical bonding and fluoride release properties. They can also absorb fluoride from external sources, but their use is limited by issues such as early water sensitivity, poor strength, and reduced wear resistance [2; 3]. To address these limitations, resin-modified glass ionomers were developed. They mitigate moisture sensitivity and low initial mechanical strength of conventional glass ionomers. Although they can release fluoride in amounts comparable to conventional cement, the fluoride release can be influenced by factors such as the type and amount of resin used in the photochemical polymerization. Polyacid-modified composite resins (compomers) combine characteristics of glass ionomer cement and light-curing composites. These resins primarily set through photo-initiated polymerization, with a limited acid-base reaction contributing to fluoride release but not to the hardening process. Fluoride release in resin composites depends on various factors, including the type and particle size of fluoride-containing fillers, resin type, silane treatment, and the polymer matrix's hydrophilicity and acidity [4].

Despite extensive research on fluoride uptake in glass ionomer cements, comparative studies with other fluoride-releasing materials are limited. This study aims to evaluate the fluoride release of two glass ionomer cements, a compomer, and a composite resin, and to assess the impact of topical fluorides on their fluoride-releasing abilities.

MATERIALS AND METHODS

The present in-vitro comparative study was performed at the College of Dental Sciences, Davangere, Karnataka

The present study aimed to compare fluoride release and uptake among four restorative materials over 42 days: Conventional Glass Ionomer Cement (GC Fuji II), Resin-Modified Glass Ionomer Cement (Vitremer, 3M), Compomer (Dyract AP, Dentsply), and Composite (Tetric N Ceram, Vivadent). Specimens of each material were prepared using disc-shaped plastic molds (Fig. 1), then immersed in deionized water. Fluoride levels in the water were measured at various intervals using a fluoride ion-selective electrode and digital ion analyzer.

Specimen Preparation

Ten specimens of each material were prepared and grouped as follows:

– Group I: Conventional Glass Ionomer Cement (GC Fuji II);

– Group II: Resin-Modified Glass Ionomer Cement (Vitremer, 3M);

– Group III: Compomer (Dyract AP, Dentsply);

– Group IV:Composite (Tetric N Ceram, Vivadent).

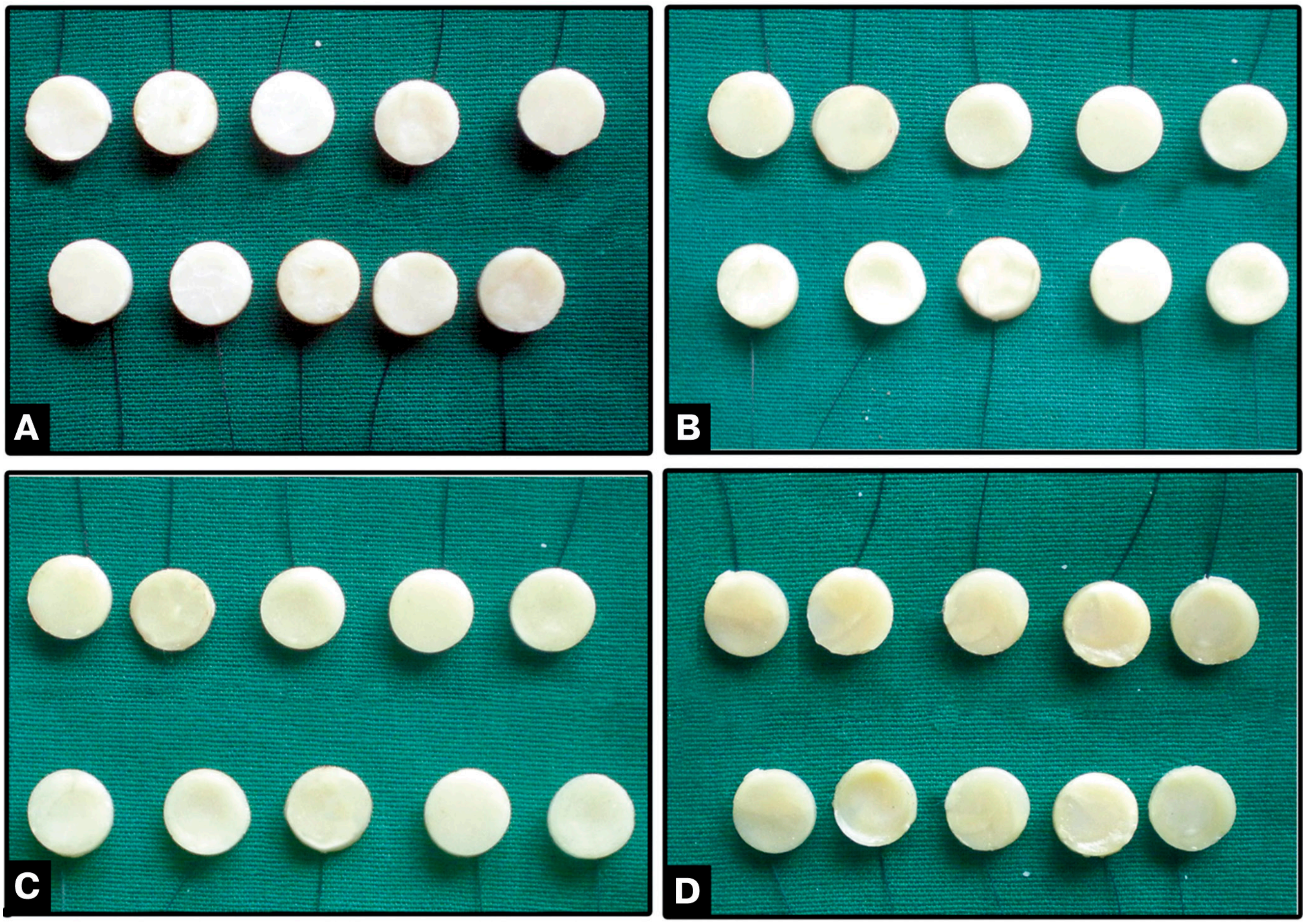

Fig. 1. Disk-shaped specimens of Group I (*A*): Conventional Glass Ionomer Cement; Group II (*B*): Resin-Modified Glass Ionomer Cement; Group III (*C*): Compomer; Group IV (*D*): Composite

Рис. 1. Образцы в форме диска из группы I (*A*): обычный стеклоиономерный цемент; группы II (*B*): стеклоиономерный цемент, модифицированный смолой; группы III (*C*): компомер; группы IV (*D*): композит

Fig. 2. Fluoride Electrode with Ion Analyser

Рис. 2. Фторидный электрод с ионным анализатором

Forty specimens in total were made using 9 mm diameter, 2 mm height plastic molds. The molds were placed on a glass slide with a mylar strip. Materials were hand-mixed according to manufacturer instructions, placed into molds, covered with a mylar strip, and pressed with a glass slide to ensure uniform discs as per the manufacturer direction.

The excess material was trimmed to 9 mm x 2 mm, and each specimen was stored in 8 ml of distilled deionized water at 37°C.

Measurement of Fluoride Release

Fluoride concentration in the water surrounding the specimen discs was measured using an Orion Fluoride Electrode (9409BN) connected to a Jenway 3330 pH meter (Fig. 2). To ensure accuracy, TISAB III (Total Ionic Strength Adjustment Buffer) was added to maintain pH between 5.0 and 5.5, freeing fluoride ions from binding and eliminating hydroxyl ion interference.

Initial Fluoride Release Measurement

After 1 day, specimens were washed with 2 ml of distilled deionized water (DDW). The 10 ml of collected solution (8 ml storage and 2 ml wash) was analyzed for fluoride concentration. Specimens were then returned to fresh 8 ml DDW. This process was repeated for 2, 3, 7, 14, and 21 days.

Fluoride Release During Topical Exposure

After 21 days, specimens were washed with 2 ml DDW and exposed to 1.23% APF gel for 5 minutes. Post-exposure, specimens were rinsed and returned to 8 ml of fresh DDW at 37°C. Fluoride release was measured daily from day 22 to day 35.

Fluoride Release Post Recharge

Following the 14-day fluoride immersion period, specimens were stored in fresh 8 ml DDW for 7 days without fluoride exposure. They were then washed with 2 ml DDW, and both solutions were collected for fluoride estimation.Out of the 10 ml collected, 3 ml was mixed with 3 ml of TISAB III buffer. Fluoride concentration was analyzed using the Orion Fluoride Electrode, with results reported in ppm (parts per million).

Statistical Analysis

The results were statistically evaluated using the Kruskal-Wallis test and Mann-Whitney U test, following assessment with the Shapiro-Wilk test, which indicated a skewed distribution. A significance level of $p < 0.05$ was set for all analyses.

RESULTS

Analysis of Initial Fluoride Release

Fig. 3 and 4 present the daily fluoride release patterns for each group throughout the study. The release patterns were generally similar across all fluoride-releasing materials, yet there were notable differences in the amount of fluoride released. Group I exhibited the highest fluoride release (median:18.36 ppm, [IQR: 18.36–18.87] on Day 1), significantly more than Groups II (14.72 ppm [IQR: 14.72–16.21]), III (8.96 ppm [IQR: 8.96–9.97]), and IV (2.4 ppm [IQR: 2.4–2.91]), with $p < 0.001$ for all comparisons (I&II, I&III, I&IV, II&III, II&IV,

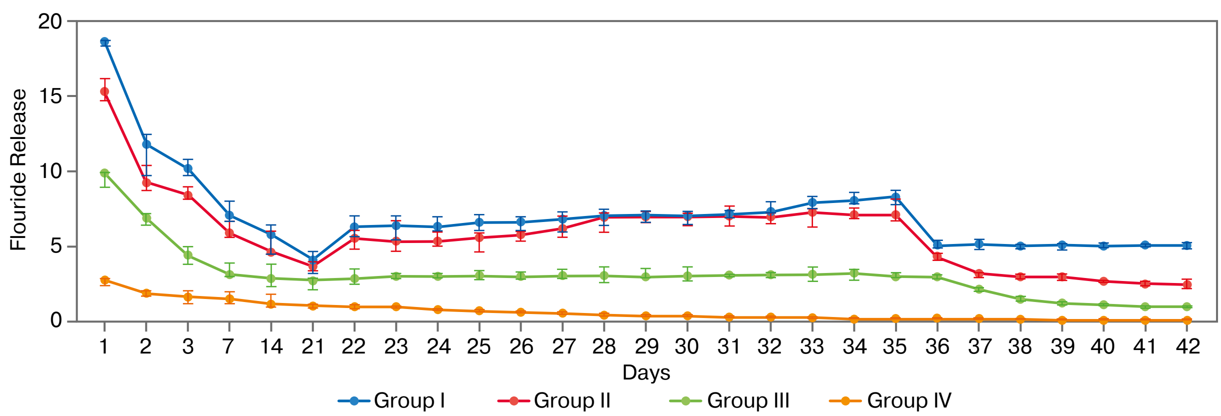

Fig. 3. Line graph illustrating the trend of fluoride release across each day, with points representing the median values

Рис. 3. Линейный график, иллюстрирующий тенденцию выделения фтора в течение каждого дня, с точками, представляющими средние значения

III&IV). All groups reached their peak fluoride release on the first day. Following this initial peak, Groups I and II experienced a more pronounced reduction in fluoride release by the second day (9.74 ppm [IQR: 9.74–12.47] for Group I, 8.76 ppm [IQR: 8.76–10.41] for Group II) compared to Groups III (6.44 ppm [IQR: 6.44–7.2]) and IV (1.72 ppm [IQR: 1.72–2.06]). This trend of decreasing fluoride release continued consistently on Day 3 (Group I: 9.75 ppm [IQR: 9.75–10.82], Group II: 8.18 ppm [IQR: 8.18–8.99], Group III: 3.83 ppm [IQR: 3.83–5.02], Group IV: 1.21 ppm [IQR: 1.21–2.06]) and 7, with $p < 0.001$ observed across all groups (I&II, I&III, I&IV, II&III, II&IV, III&IV).

Analysis of Fluoride Release During Fluoride Immersion Period

Fig. 4 illustrate the daily fluoride release from each group during immersion in 1.23% APF gel. On Day 22, which marked the first day of fluoride application, there was a statistically significant difference in fluoride uptake among Groups I, II, III, and IV (Group I: 5.69 ppm [IQR: 5.69–7.04], Group II: 4.85 ppm [IQR: 4.85–6.1], Group III: 2.5 ppm [IQR: 2.5–3.5], Group IV: 0.87 ppm [IQR: 0.87–1.12]). This trend continued through Day 32, the 14th day of fluoride application, where significant differences in fluoride uptake were again observed between the groups.

Table 1. Descriptive statistics (median and interquartile range) and Intergroup comparisons for fluoride release on each day

Таблица 1. Описательная статистика (медиана и межквартильный диапазон) и межгрупповые сравнения по выделению фтора в течение каждого дня

Days	Groups				*p*-value
	I (*n* = 10)	II (*n* = 10)	III (*n* = 10)	IV (*n* = 10)	
1d	18.36 (18.36–18.87)a	14.72 (14.72–16.21)b	8.96 (8.96–9.97)c	2.4 (2.4–2.91)d	<0.0001*
2d	9.74 (9.74–12.47)a	8.76 (8.76–10.41)b	6.44 (6.44–7.2)c	1.72 (1.72–2.06)d	<0.0001*
3d	9.75 (9.75–10.82)a	8.18 (8.18-8.99)b	3.83 (3.83–5.02)c	1.21 (1.21–2.06)d	<0.0001*
7d	6.88 (6.88–8.05)a	5.64 (5.64–6.7)b	3 (3–3.92)c	1.19 (1.19–2)d	<0.0001*
14d	4.49 (4.49–6.44)a	3.93 (3.93–6.05)b	2.34 (2.34–3.83)c	0.97 (0.97–1.82)d	<0.0001*
21d	3.24 (3.24–4.68)a	3.41 (3.41–3.99)b	2.12 (2.12–2.91)c	0.9 (0.9–1.15)d	<0.0001*
22d	5.69 (5.69–7.04)a	4.85 (4.85–6.1)b	2.5 (2.5–3.5)c	0.87 (0.87–1.12)d	<0.0001*
23d	5.44 (5.44–7.06)a	4.69 (4.69–6.73)b	2.87 (2.87–3.2)c	0.92 (0.92–1.05)d	<0.0001*
24d	6.08 (6.08–6.99)a	5.06 (5.06–6.01)b	2.87 (2.87–3.2)c	0.76 (0.76–0.83)d	<0.0001*
25d	6.07 (6.07–7.14)a	4.65 (4.65–5.91)b	2.8 (2.8–3.39)c	0.65 (0.65–0.8)d	<0.0001*
26d	6.08 (6.08–6.99)a	5.36 (5.36–6)b	2.83 (2.83–3.33)c	0.61 (0.61–0.71)d	<0.0001*
27d	5.99 (5.99–7.33)a	5.62 (5.62–7.04)b	2.9 (2.9–3.47)c	0.46 (0.46–0.66)d	<0.0001*
28d	6.43 (6.43–7.51)a	5.96 (5.96–7.23)b	2.61 (2.61–3.67)c	0.34 (0.34–0.58)d	<0.0001*
29d	6.6 (6.6–7.37)a	6.6 (6.6–7.32)b	2.87 (2.87–3.55)c	0.33 (0.33-0.45)d	<0.0001*
30d	6.94 (6.94–7.37)a	6.4 (6.4–7.34)b	2.73 (2.73–3.66)c	0.35 (0.35–0.45)d	<0.0001*
31d	6.95 (6.95–7.41)a	6.38 (6.38–7.69)b	2.96 (2.96–3.2)c	0.28 (0.28–0.38)d	<0.0001*
32d	6.53 (6.53–8)a	6.85 (6.85–7.22)b	2.94 (2.94–3.27)c	0.27 (0.27–0.35)d	<0.0001*
33d	7.53 (7.53–8.34)a	6.31 (6.31–7.88)b	2.69 (2.69–3.64)c	0.23 (0.23–0.27)d	<0.0001*
34d	7.87 (7.87–8.63)a	6.85 (6.85–7.61)b	2.76 (2.76–3.47)c	0.17 (0.17–0.21)d	<0.0001*
35d	7.79 (7.79–8.75)a	6.72 (6.72–8.15)b	2.95 (2.95–3.26)c	0.18 (0.18–0.22)d	<0.0001*
36d	4.93 (4.93–5.43)a	4.08 (4.08–4.55)b	2.88 (2.88–3.12)c	0.17 (0.17–0.23)d	<0.0001*
37d	4.81 (4.81–5.48)a	2.96 (2.96–3.26)b	2 (2–2.24)c	0.16 (0.16–0.23)d	<0.0001*
38d	4.88 (4.88–5.17)a	2.84 (2.84–3.16)b	1.4 (1.4–1.67)c	0.13 (0.13–0.16)d	<0.0001*
39d	4.78 (4.78–5.21)a	2.74 (2.74–3.17)b	1.1 (1.1–1.32)c	0.11 (0.11–0.15)d	<0.0001*
40d	4.94 (4.94–5.24)a	2.65 (2.65–2.74)b	1.07 (1.07–1.15)c	0.1 (0.1–0.13)d	<0.0001*
41d	4.98 (4.98–5.18)a	2.37 (2.37–2.67)b	0.91 (0.91–1.02)c	0.1 (0.1–0.14)d	<0.0001*
42d	4.86 (4.86–5.26)a	2.19 (2.19–2.82)b	0.95 (0.95–0.99)c	0.1 (0.1–0.13)d	<0.0001*

Note: *n* – number of samples per group; * statistically significant ($p \leqslant 0.05$). Different letters indicate significant differences between the pairs.

Примечания: *n* – количество образцов в группе; * статистически значимый ($p \leqslant 0.05$). Разные буквы указывают на существенные различия между парами.

When comparing the fluoride release on Day 22 with Day 35, Group III showed no significant change (Day 35: 2.95 ppm [IQR: 2.95–3.26], p = 0.9499). In contrast, Groups I (7.79 ppm [IQR: 7.79–8.75], $p < 0.0001$) and II (6.72 ppm [IQR: 6.72–8.15], $p < 0.0001$) exhibited a notable increase in fluoride release on Day 35 compared to Day 22, suggesting these groups had a greater recharge capacity at the end of the immersion period. Group IV showed a significant increase from Day 22 to Day 35 (p = 0.0014), indicating improved fluoride release dynamics.

Analysis of fluoride release (ppm) following the 14-day immersion period in 1.23% APF gel is summarized in Fig. 5, which compares daily fluoride release across different groups.

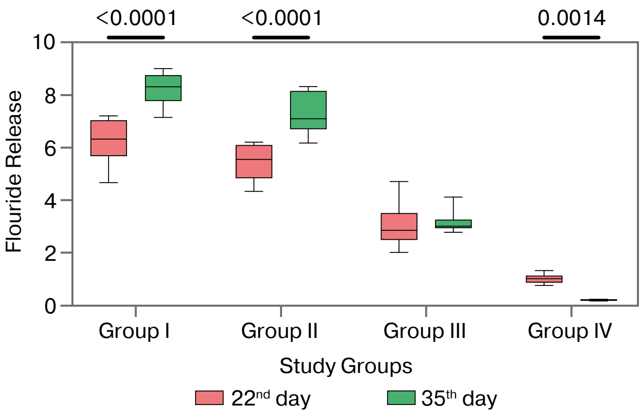

Fig. 4. Box and Whisker Plot showing the fluoride release from each group during immersion in 1.23% APF gel with significant comparisons marked above

Рис. 4. График в виде прямоугольника и усиков, показывающий выделение фтора в каждой группе при погружении в 1,23%-й гель APF, со значимыми сравнениями, отмеченными выше

In Group I, the median fluoride release was 3.24 (IQR 3.24–4.68) at 21 days, 4.93 (IQR 4.93–5.43) at 36 days, and 4.86 (IQR 4.86–5.26) at 42 days. Pairwise comparisons revealed significant differences between 21 vs. 36 days ($p < 0.0001$) and 21 vs. 42 days ($p < 0.0001$), while no significant difference was observed between 36 and 42 days (p = 0.8170).

For Group II, the median fluoride release was 3.41 (IQR 3.41–3.99) at 21 days, 4.08 (IQR 4.08–4.55) at 36 days, and 2.19 (IQR 2.19–2.82) at 42 days. Significant differences were noted between 21 vs. 36 days (p = 0.0003), 21 vs. 42 days ($p < 0.0001$), and 36 vs. 42 days ($p < 0.0001$).

In Group III, the median fluoride release was 2.12 (IQR 2.12–2.91) at 21 days, 2.88 (IQR 2.88–3.12) at 36 days, and 0.95 (IQR 0.95–0.99) at 42 days. No significant difference was found between 21 and 36 days (p = 0.0613), but significant differences were observed between 21 vs. 42 days ($p < 0.0001$) and 36 vs. 42 days ($p < 0.0001$).

Finally, Group IV had a median fluoride release of 0.90 (IQR 0.90–1.15) at 21 days, 0.17 (IQR 0.17–0.23) at 36 days, and 0.10 (IQR 0.10–0.13) at 42 days. Significant differences were detected between 21 vs. 36 days ($p < 0.0001$) and 21 vs. 42 days ($p < 0.0001$), while no significant difference was found between 36 and 42 days (p = 0.9517).

DISCUSSION

Dental caries result from an imbalance between demineralization and remineralization of dental hard tissues, influenced by pathological factors such as acidogenic bacteria and reduced salivary function, alongside protective factors like salivary flow and fluoride [5; 6]. Fluoride plays a pivotal role in caries prevention by enhancing enamel resistance, promoting remineralization, and inhibiting plaque bacteria, thereby reducing bacterial adhesion and limiting metabolic activity between meals [7].

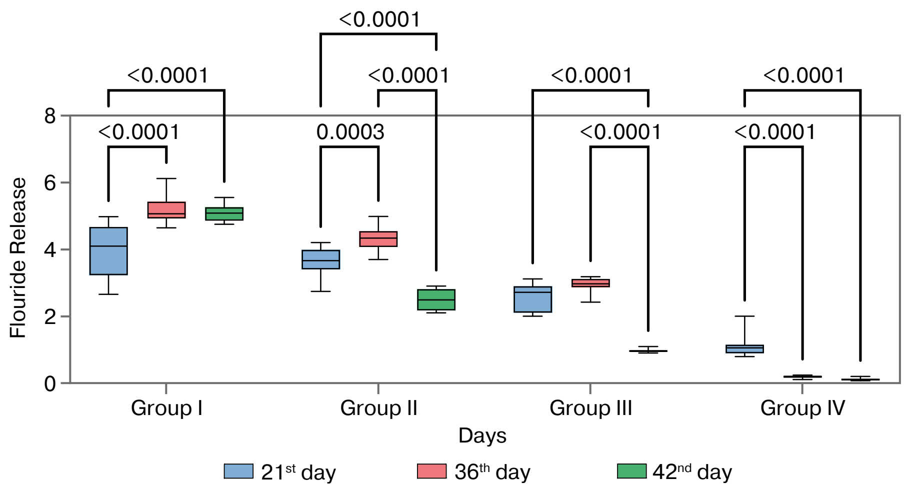

Fig. 5. Box and Whisker Plot showing the Inter-group Comparison of Fluoride Release after the 14 days of Immersion In 1.23% APF Gel with significant pairwise comparisons marked overhead.

Рис. 5. График в виде прямоугольника и усиков, показывающий межгрупповое сравнение выделения фтора после 14 дней погружения в 1,23%-й гель APF, со значительными попарными сравнениями, отмеченными выше

A study by Kidd et al. found that 75% of restorative procedures involved replacements, with 40% attributed to secondary caries, underscoring fluoride's essential role in preventing recurrent caries [8]. To sustain effective fluoride levels, a rechargeable, slow-release fluoride system in dental materials is highly desirable [9; 10]. This study focused on evaluating two critical aspects of fluoride's role in caries prevention: fluoride release and uptake from four tooth-colored restorative materials – conventional glass ionomer, resin-modified glass ionomer, compomer, and fluoride-releasing composite resin.

Various methods exist for estimating fluoride ion release, including distillation with spectrophotometric analysis, indirect methods, and ion-selective techniques. However, many of these methods fail to accurately measure fluoride due to its complexation with metals like aluminum. This study employed the ion-selective method combined with Total Ionic Strength Adjustment Buffer (TISAB), effectively dissociating fluoride from polyvalent cations, ensuring precise measurement [11; 12].

Levallois and Fovet found that resin-modified glass ionomer cements released more fluoride in water than in artificial saliva, due to the presence and thickness of a CaF_2 layer [13]. Similarly, El Mallakh and Sarkar showed that conventional glass ionomer cements released more fluoride in distilled water than in artificial saliva [12]. This study focused on evaluating maximum fluoride release from two glass ionomer cements, a compomer, and a composite resin using deionized water to avoid interference from other variables. Conventional GIC, known as the "Gold Standard" for fluoride release, was used as a comparison benchmark [13].

Fluoride release from materials typically peaks initially and then decreases over time. In this study, fluoride release was measured on days 1, 2, 3, 7, 14, and 21. The results showed that conventional glass ionomer cement released the most fluoride, followed by resin-modified glass ionomer cement, compomer, and composite resin, which released the least. The conventional and resin-modified glass ionomers exhibited a high initial release that sharply decreased, while the compomer and composite demonstrated significantly lower release. This pattern is consistent with previous studies, where conventional glass ionomer cement showed the highest initial fluoride release due to its higher fluoride content. Resin-modified glass ionomer cement released less fluoride than conventional glass ionomer cement, likely because the resin matrix encapsulates fluoride ions, slowing their release. Compomer exhibited even lower fluoride release, potentially due to its more tightly bound or less hydrophilic matrix. Composite resin had the lowest fluoride release, likely due to the poor solubility of its fluoride-containing salts [14; 15]. The rapid initial decrease in fluoride release observed in the conventional and resin-modified glass ionomers, known as the "Initial Burst Effect", is likely due to the dissolution of glass particles in the polyalkenoic acid during setting. Following this burst, fluoride release slows as the glass continues to dissolve in the acidic environment of the hydrogel matrix [16].

Topical fluoride treatments vary in type and concentration. A study by Ahn et al. found that 1.23% APF gel released more fluoride compared to neutral fluoride gel and demonstrated superior fluoride deposition in enamel. Given that higher fluoride concentration leads to greater fluoride uptake, the current study utilized 1.23% APF gel as the recharge solution [17].

In this study, a statistically significant difference in fluoride release was observed during the fluoride immersion period. Both conventional glass ionomer cement and resin-modified glass ionomer cement exhibited higher fluoride release compared to compomer and composite materials after recharge. Notably, fluoride release was greater on day 34 compared to day 22 for the conventional and resin-modified glass ionomers, consistent with previous studies [18; 19].

Okuyama et al. similarly evaluated fluoride release and uptake in various dental materials. They found that fluoride release peaked on day 1 and then decreased. After 21 days, materials were exposed to 1000 ppm NaF daily for 14 days. Conventional and resin-modified glass ionomers showed an increase in fluoride release on day 14, likely due to fluoride diffusion into the material matrix. Compomer and composite materials, however, did not show fluoride reuptake. The higher fluoride release observed on day 35, compared to day 22, was attributed to additional fluoride binding in the glass ionomer cement [15].

Fluoride release analysis after 14 days of immersion revealed a statistically significant difference among the materials. Conventional glass ionomer cement released the most fluoride, although this gradually decreased over the next 7 days, consistent with other studies [17; 18].

Rothwell et al. also investigated fluoride release in resin-modified glass ionomers, a compomer, and a conventional glass ionomer after exposure to fluoridated toothpaste. They observed that fluoride release increased the day after exposure but returned to baseline within 3 days, likely due to superficial absorption rather than deep diffusion [18]. Post-fluoride application, fluoride release depends on initial release and material porosity. The higher resin content in resin-modified glass ionomer, compomer, and composite likely contributed to their lower fluoride release compared to conventional glass ionomer cement [2; 20–22]. Overall conventional glass ionomer cement exhibited the highest fluoride uptake and re-release, followed by resin-modified glass ionomer cement. Although other groups released some fluoride, they did not demonstrate significant fluoride uptake.

This study presents several strengths, including a comparative analysis that directly evaluates fluoride release among various fluoride-releasing materials, thereby enhancing our understanding of their effectiveness. The clinical relevance of the findings is notable, as they focus on materials commonly used in dental practice, which can inform clinical decisions and ultimately improve patient care. Furthermore, the standardized methodology employed for measuring fluoride release ensures that the results are reliable and reproducible.

LIMITATIONS

Despite its strengths, this study has some limitations. First, the research is conducted in an in vitro setting, which may not fully replicate the complexities of the oral environment. Additionally, the assessment of fluoride release is limited to a short duration, potentially overlooking long-term behaviors of the materials in clinical settings. Lastly, while multiple fluoride-releasing materials are tested, the study may not encompass all available options, limiting the findings' generalizability.

CONCLUSION

The study revealed that among the evaluated materials, GIC exhibited the highest fluoride release, particularly on Day 1, significantly outperforming the other materials. This high fluoride release capability positions it as the most effective choice for enhancing dental health through its cariostatic properties. While RMGIC also demonstrated substantial fluoride release, its performance was inferior to that of GC Fuji II. Conversely, the Compomer and Composite Resin displayed comparatively lower fluoride release levels. Therefore, for optimal fluoride release and potential benefits in preventing caries, Conventional Glass Ionomer cement is recommended as the preferred material in clinical applications.

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