|| Online ISSN: 2589-9139 || Print ISSN: 2589-9120 ||
International Journal of Medical Science and Applied Research (IJMSAR)
Available Online at www.ijmsar.com
NLM - National Library of Medicine ID: 101775327
Volume - 8 , Issue - 4; August : 2025; Page No. 01-07

Article Type: Original Research Article

Comparative Evaluation of Cumulative Fluoride Release Profiles of Glass Ionomer Cements

[1]Dr. Sudeep H.M**,** Professor, Triveni Institute of Dental Sciences, Hospital and Research Centre (Affiliated to Pt. Deendayal Upadhyay Memorial Health Sciences and Ayush University of Chhattisgarh), Vidya Sthali, Bodri, Bilaspur, 495220

Corresponding Author: Dr. Sudeep H.M**,** Professor, Triveni Institute of Dental Sciences, Hospital and Research Centre (Affiliated to Pt. Deendayal Upadhyay Memorial Health Sciences and Ayush University of Chhattisgarh), Vidya Sthali, Bodri, Bilaspur, 495220

Conflict of interest: Nil

This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org /licenses/ by/4.0).

Abstract

Objective: To compare the fluoride release profiles of four glass ionomer cements (GICs)-GC Gold Label 2 (GC Corporation, Japan), Micron Superior (Prevest DenPro, India), Neocem 2 (Orikam, India) and Prime Cem 2 (Prime, India) over 21 days.

Materials and Methods: Forty cylindrical specimens (5 mm × 2 mm) were prepared from 4 groups of 10 each. Samples were stored at 37°C and fluoride release was measured at time points (Day 1, Day 2, Day 3, Day 4, Day 5, Day 6, Day 7, Day 14, Day 21) using a fluoride ion-selective electrode with TISAB buffer for accuracy. Statistical analysis was performed using unpaired t-tests and two-way ANOVA and Tukey Kramer multiple comparison tests (p=0.05).

Results: Micron Superior released the most fluoride followed by GC Gold Label 2, Neocem 2 and Prime Cem 2. Intergroup differences were statistically significant ($p < 0.05$).

Conclusion: Extent of glass ionomer matrix plays an important role in determining fluoride releasing ability. Micron Superior (Prevest DenPro, India) demonstrated the highest fluoride-releasing potential, indicating its better performance in cariogenic environments. These findings can guide material selection in patients at high risk of dental caries.

Keywords: demineralization, remineralization, fluoride, matrix erosion

Introduction

The prevention and control of dental caries remains a primary objective in modern restorative dentistry. Among various restorative materials, glass ionomer cements (GICs) have stood out for their unique properties, particularly their ability to release fluoride—a feature that not only helps in remineralization of enamel and dentin but also inhibits cariogenic bacterial activity [1–3]. Originally developed by Wilson and Kent in the 1970s, GICs have undergone several modifications to improve their clinical performance, aesthetics, and longevity while

retaining their ion-releasing capabilities [4]. The fluoride-releasing property of GICs is perhaps their most biologically significant feature. Fluoride ions exert a multifactorial cariostatic effect: they reduce enamel solubility, enhance remineralization of early carious lesions, and inhibit key enzymes in acidogenic bacteria such as *Streptococcus mutans* [5,6]. As a result, fluoride-releasing materials are especially beneficial in high caries-risk patients, in minimally invasive dentistry, and in pediatric and geriatric populations. Fluoride release from GICs is governed by both material-intrinsic factors such as the glass composition, particle size, powder-liquid ratio, and setting characteristics—and extrinsic factors like pH and composition of the surrounding environment[7]. Conventionally, fluoride release is described as a biphasic pattern: an initial "burst effect" in the first 24 hours, followed by a slower, sustained release over time [8]. This pattern is especially important for the material's caries-inhibiting properties during the critical post-restorative period when bacterial invasion is most active. The medium in which the GIC is immersed significantly affects fluoride ion diffusion.[9–11]. Comparing fluoride release provides clinically relevant insight into the material's performance under varying intraoral conditions. While GC Gold Label 2 from GC Corporation (Japan) is a well-established and widely studied conventional GIC, several newer formulations have entered the Indian market in recent years. These include Micron Superior (Prevest DenPro, India), Neocem 2 (Orikam, India), and Prime Cem 2 (India), all of which are marketed as high-performance restorative materials with fluoride-releasing potential. However, limited peer-reviewed data exist on the fluoride release behavior of these newer materials. Understanding the fluoride release dynamics of these GICs is critical for evaluating their real-world effectiveness, especially in patients prone to low salivary pH or poor oral hygiene. This study aims to conduct a short-term comparative analysis of fluoride ion release from four different conventional GICs- GC Gold Label 2 (GC Corporation, Japan), Micron Superior (Prevest DenPro, India) , Neocem 2 (Orikam, India), and Prime Cem 2 (Prime, India) over a 21 day period. The findings are expected to provide insights into the suitability of these materials for preventive and restorative strategies, especially in cariogenic oral environments.

Methodology

A total of forty cylindrical samples, each measuring 5 mm in diameter and 2 mm in height, were fabricated using four different glass ionomer restorative materials- Group 1(n=10): GC Gold Label 2 (GC Corporation, Japan), Group 2 (n=10): Micron Superior (Prevest DenPro, India), Group 3 (n=10): Neocem 2 (Orikam, India) and Group 4 (n=10): Prime Cem 2 (Prime, India). Glass slides and a Mylar strip were placed over the specimen's upper surface, and it was left to cure chemically for 10 minutes at room temperature. A light source (Pencure, J Morita MFG company., Japan) was used for 40 seconds to cure the light-curing materials from top to bottom. In the center of the sample, an extra 20 s of light was applied from both sides. All specimens were incubated at 37°C for 24 hours to simulate oral conditions. Each group's specimens (n = 10) were then placed in polyethylene vials with 1 ml of deionized water and kept in an incubator set at 37°C. A uniform immersion protocol was followed across all groups to assess fluoride release. After 24hours, the specimens were carefully removed from the containers, rinsed with 1 ml of deionised water to eliminate surface residues, and returned to a new vial containing 1ml of deionized water.

Cumulative fluoride ion release was measured over a 21-day period at five designated intervals: Day 1, Day 2, Day 3, Day 4, Day 5, Day 6, Day 7, Day 14, Day 21. The concentration of fluoride in the storage solutions was analyzed using a fluoride ion-selective electrode (Model 720A, Orion Research Inc., Boston, MA, USA), which was calibrated before each session. Electrode slope verification was performed daily and after every batch of 10 measurements to ensure instrument accuracy and consistency. To stabilize the ionic environment and facilitate accurate fluoride quantification, Total Ionic Strength Adjustment Buffer (TISAB) was added to all sample solutions prior to measurement. TISAB serves to buffer the pH, maintain consistent ionic strength, and release fluoride ions from potential complexes. It includes 2% CDTA (1, 2-cyclohexanediaminetetraacetic acid), a chelating agent that preferentially binds polyvalent cations, thereby liberating complexed fluoride ions for precise detection.

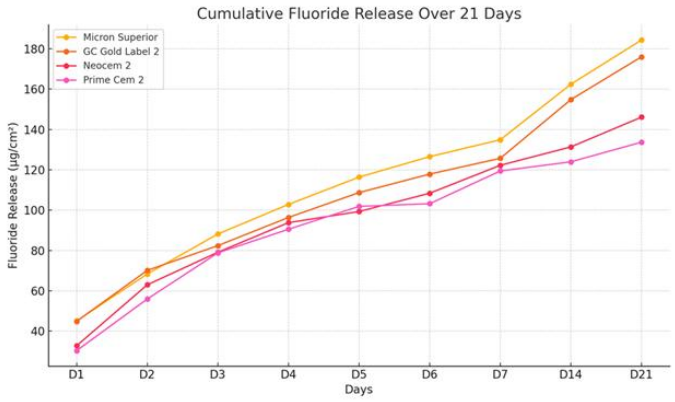
Results

Table 1: Cumulative fluoride release from tested materials (µg/cm^2); standard deviations are given in parenthesis

Cumulative Fluoride Release (µg/cm²)

Days	D1	D2	D3	D4	D5	D6	D7	D14	D21
Micron Superior	45.12 (6.02)	68.34 (7.98)	88.17 (8.55)	102.84 (9.76)	116.40 (10.33)	126.55 (11.42)	134.92 (11.9)	162.47 (13.5)	184.38 (14.8)
GC Gold Label 2	44.88 (5.47)	70.13 (7.24)	82.41 (8.13)	96.38 (9.65)	108.72 (10.96)	117.90 (11.74)	125.71 (11.5)	154.86 (13.19)	176.05 (14.96)
Neocem 2	32.74 (8.24)	62.99 (9.22)	79.13 (9.95)	93.81 (10.42)	99.33 (11.11)	108.40 (11.84)	122.26 (12.6)	131.38 (14.77)	146.14 (15.92)
Prime Cem 2	30.34 (4.58)	55.92 (5.71)	78.83 (6.79)	90.54 (4.91)	101.87 (8.01)	103.21 (7.10)	119.44 (6.16)	123.99 (5.59)	133.72 (8.67)

Figure 1: Cumulative fluoride release of dental materials



Fluoride ion release from the four tested glass ionomer cements- GC Gold Label 2 (GC Corporation, Japan), Micron Superior (Prevest DenPro, India), Neocem 2 (Orikam, India), and Prime Cem 2 (Prime, India) were evaluated over a 21-day period, with measurements taken at nine specific intervals. The results were expressed in (µg/cm^2) and presented graphically in graph (Figure 1), which illustrate the comparative fluoride release across all groups and time points. Statistical analysis was performed using unpaired "t" tests and one-way ANOVA. A highly significant difference was observed in fluoride release ($p < 0.001$). Throughout the study duration, all materials consistently released ties varied significantly between them.

Intergroup comparison

The cumulative fluoride release (μg/cm²) of the four glass ionomer cements (GICs) over a 21-day period showed significant intergroup variation. Micron Superior exhibited the highest fluoride release consistently across all time points. On Day 1, Micron Superior released 45.12 ± 6.02 μg/cm², which increased progressively to 134.92 ± 11.9 μg/cm² by Day 7, and reached 184.38 ± 14.8 μg/cm² by Day 21. GC Gold Label 2 demonstrated a comparable release pattern, starting at 44.88 ± 5.47 μg/cm² on Day 1 and rising to 125.71 ± 11.5 μg/cm² on Day 7, ultimately reaching 176.05 ± 14.96 μg/cm² at the end of Day 21. While the release was initially similar to Micron Superior, GC Gold Label 2 showed slightly lower values at each subsequent time point. Neocem 2 presented a moderate fluoride release, starting at 32.74 ± 8.24 μg/cm² on Day 1 and increasing to 122.26 ± 12.6 μg/cm² by Day 7. By Day 21, the cumulative fluoride release reached 146.14 ± 15.92 μg/cm², which was lower than both Micron Superior and GC Gold Label 2. Prime Cem 2 recorded the lowest cumulative fluoride release throughout the evaluation period. The release on Day 1 was 30.34 ± 4.58 μg/cm², rising to 119.44 ± 6.16 μg/cm² by Day 7, and reaching 133.72 ± 8.67 μg/cm² by Day 21. Overall, Micron Superior demonstrated the greatest cumulative fluoride release over the 21-day period, followed closely by GC Gold Label 2. Neocem 2 and Prime Cem 2 released comparatively lower fluoride amounts throughout the evaluation period.

Discussion

The present study aimed to compare the fluoride ion release of four commercially available glass ionomer cements (GICs)—Micron Superior, GC Gold Label 2, Neocem 2, and Prime Cem 2—over a 21-day period in deionized water. Fluoride release is one of the most critical biological properties of GICs due to its well-documented role in inhibiting demineralization, enhancing remineralization, and suppressing bacterial metabolism, especially of Streptococcus mutans [5,12,13]. Our findings demonstrated that Micron Superior released the highest amount of fluoride at all evaluated time points, followed by GC Gold Label 2, Neocem 2, and Prime Cem 2. These differences were statistically significant ($p < 0.001$), supporting the hypothesis that GICs differ in their fluoride-releasing ability based on formulation and composition. The initial burst effect observed on Day 1, followed by a sustained release pattern, is consistent with the biphasic release behavior previously described in the literature [14,15]. This pattern is clinically beneficial, as the early high fluoride levels may provide immediate cariostatic protection post-restoration, while the sustained release contributes to long-term maintenance of oral health [7]. The superior performance of Micron Superior may be attributed to its powder-to-liquid ratio, smaller glass particle size, and higher content of reactive fluoroaluminosilicate glass, which increases fluoride availability [16]. Studies have shown that GICs with higher glass content and smaller particle size release more fluoride due to increased surface area and reactivity [17,18]. Additionally, the use of polyacrylic acid of optimal molecular weight in some newer formulations can enhance diffusion and fluoride ion exchange [11]. GC Gold Label 2, a benchmark material, demonstrated consistently high fluoride release but slightly lower than Micron Superior. Previous studies evaluating GC materials have shown reliable fluoride release and clinical durability, reinforcing its reputation [19]. Neocem 2, although positioned as a high-performance material, demonstrated moderate release. Its lower fluoride emission could be

due to differences in matrix structure or glass composition, potentially reducing fluoride solubility [20]. Prime Cem 2 consistently exhibited the lowest fluoride release, suggesting it may be less suited for high-caries-risk scenarios where fluoride activity is paramount. The clinical implication of these findings is significant. In populations with high caries activity—such as children, elderly patients, and individuals with xerostomia—materials with superior fluoride release (like Micron Superior and GC Gold Label 2) are preferable to enhance the preventive effects of restorations [21,22]. Moreover, fluoride-releasing materials also play a role in preventing secondary caries and in atraumatic restorative treatment (ART) settings where professional dental care access is limited [23,24]. Despite the promising results, the study has limitations. It was conducted under in vitro conditions using deionized water, which does not fully replicate the dynamic pH changes, salivary proteins, and ionic interactions of the oral environment [2]. The results may differ in media such as artificial saliva or lactic acid, where pH variation and ionic competition influence fluoride release [25]. Additionally, only cumulative fluoride release up to 21 days was evaluated. Long-term data (e.g., over 3–6 months) would provide more insight into the material's prolonged anticariogenic potential [26]. Future studies should consider evaluating fluoride recharge ability, pH cycling conditions, antibacterial efficacy, and mechanical properties such as wear resistance and bond strength. Such data would offer a more comprehensive view of the material's suitability for clinical use, particularly in high caries-risk or low-resource settings.

Conclusion

Within the limitations of this in vitro study, it can be concluded that fluoride release from glass ionomer cements varies significantly among different formulations. Micron Superior exhibited the highest cumulative fluoride release over the 21-day period, followed by GC Gold Label 2, Neocem 2, and Prime Cem 2. These differences were statistically and clinically significant. The findings underscore the importance of material composition—particularly the glass content and matrix structure—in influencing fluoride ion release. Given its superior fluoride-releasing ability, Micron Superior may be better suited for patients at high risk of dental caries or those requiring enhanced preventive care. These results may help clinicians make more informed decisions regarding the selection of restorative materials in cariogenic environments. Further long-term and in vivo studies are recommended to validate these observations under clinical conditions.

References

1. Sidhu SK, Nicholson JW. A review of glass-ionomer cements for clinical dentistry. J Funct Biomater. 2016;7(3):16.
2. Wiegand A, Buchalla W, Attin T. Review on fluoride-releasing restorative materials—fluoride release and uptake characteristics, antibacterial activity and influence on caries formation. Dent Mater. 2007;23(3):343–362.
3. Forsten L. Fluoride release and uptake by glass-ionomers and related materials and its clinical effect. Biomaterials. 1998;19(6):503–508.
4. Wilson AD, Kent BE. The glass-ionomer cement: a new translucent dental filling material. J Appl Chem Biotechnol. 1971;21(11):313.
5. Ten Cate JM. Current concepts on the theories of the mechanism of action of fluoride. Acta Odontol Scand. 1999;57(6):325–329.
6. Featherstone JD. The science and practice of caries prevention. J Am Dent Assoc. 2000;131(7):887–899.

7. Xie D, Brantley WA, Culbertson BM, Wang G. Mechanical properties and microstructures of glass-ionomer cements. Dent Mater. 2000;16(2):129–138.
8. Hatibović-Kofman Š, Koch G, Fänge P. Release of fluoride and aluminium from different dental materials in vitro. Swed Dent J. 1997;21(1-2):9–19.
9. Czarnecka B, Nicholson JW. Ion release by resin-modified glass-ionomer cements into water and lactic acid solutions. J Mater Sci Mater Med. 2006; 17 (7):597–602.
10. Dionysopoulos D, Koliniotou-Koumpia E, Helvatzoglou-Antoniades M. Fluoride release and recharge potential of contemporary dental materials. Eur Arch Paediatr Dent. 2013;14(5):329–335.
11. Yap AU, Tham SY, Zhu LY, Lee HK. Short-term fluoride release from various aesthetic restorative materials. Oper Dent. 2002;27(3):259–265.
12. Marinho VC, Higgins JP, Logan S, Sheiham A. Fluoride toothpastes for preventing dental caries in children and adolescents. Cochrane Database Syst Rev. 2003;(1):CD002278.
13. Featherstone JD. Prevention and reversal of dental caries: role of low-level fluoride. Community Dent Oral Epidemiol. 1999;27(1):31–40.
14. Czarnecka B, Limanowska-Shaw H, Nicholson JW. Ion release by resin-modified glass-ionomer cements into water and lactic acid solutions. J Dent. 2002;30(1):23–27.
15. Verbeeck RM, De Maeyer EA, Martens LC. Fluoride release from glass ionomer cements. In: Fluoride-releasing dental materials. Basel: Karger Publishers; 1996. p. 59–66.
16. Hatibovic-Kofman S, Koch G, Mjör IA. Glass ionomer materials in primary teeth: a literature review. J Dent. 2001;29(4):307–316.
17. De Moor RJ, Martens LC, Vanobbergen J, Verbeeck RM. Fluoride release profiles of restorative glass ionomer formulations. Dent Mater. 2004;20(6):522–528.
18. Forsten L. Short- and long-term fluoride release from glass ionomers and other fluoride-containing filling materials in vitro. Scand J Dent Res. 1990;98(2):179–185.
19. Momoi Y, McCabe JF. Fluoride release from light-activated glass ionomers. Dent Mater. 1993; 9(3): 151–154.
20. Itota T, Carrick TE, Yoshiyama M, McCabe JF. Fluoride release and recharge in giomers, compomers and resin composites. Dent Mater. 2004;20(9):789–795.
21. Ngo HC, Mount G, McIntyre J, Tuisuva J, Von Doussa R. Chemical exchange between glass-ionomer restorations and residual carious dentine in permanent molars: an in vivo study. J Dent. 2006;34(8):608–613.
22. Yip HK, Smales RJ, Ngo HC. Comparison of conventional and resin-modified glass-ionomer restorations in primary molars: a review. Aust Dent J. 1999;44(1):1–7.
23. Frencken JE, Leal SC, Navarro MF. Twenty-five-year atraumatic restorative treatment (ART) approach: a comprehensive overview. Clin Oral Investig. 2012;16(5):1337–1346.
24. Donly KJ. Fluoride release and uptake characteristics of glass ionomers. Pediatr Dent. 1994;16(5):302–306.
25. El Mallakh BF, Sarkar NK. Fluoride release from glass-ionomer cements in deionized water and artificial saliva. Dent Mater. 1990;6(2):118–122.

26. Nicholson JW, Czarnecka B. The biocompatibility of resin-modified glass-ionomer cements for dentistry. Dent Mater. 2008;24(12):1702–1708.