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Bleaching-induced microleakage among tooth-colored Class V restorative materials: Laboratory study

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Abstract:
High-concentration bleaching agents may affect the tooth-restoration interface and increase marginal leakage in Class V restorations. This *in vitro* study restored 90 extracted human premolars with resin-modified glass ionomer cement (RMGIC), Cention N, or Filtek Z350XT nanofilled composite (n=30 each), with bleached and non-bleached subgroups of 15 specimens. Specimens were exposed to 35% hydrogen peroxide as assigned, immersed in 0.5% basic fuchsin, sectioned buccolingually and examined under a stereomicroscope at 10× magnification. Nanofilled composite showed the greatest microleakage followed by Cention N, while RMGIC showed the least; bleached subgroups generally showed greater leakage than their corresponding non-bleached controls and the RMGIC-Cention N difference was not significant. Thus, bleaching increased marginal leakage of the tested materials with RMGIC providing the most favorable seal and nanofilled composite the highest leakage.

Keywords: Resin-modified glass ionomer cement (RMGIC), Cention N, nanofilled composite, bleaching agent, microleakage, Class V restoration

Background:
Cervical lesion remains a significant restorative challenge in dentistry because these class V cavities often extend across both enamel and dentin; create difficulties in achieving an optimal seal with any restorative material **[1]**. Hence one of the main concerns with these kinds of restorations is the tendency towards microleakage, especially at gingival margin situated on dentinal surface **[2]**. In contemporary dentistry, several restorative materials *i.e.* resin-modified glass ionomer cement (RMGIC), composite resins and cention-N are recommended for restoring a class V lesion. RMGIC combines the properties of conventional glass ionomer cement with resin components, incorporating fluoroaluminosilicate glass, polyacrylic acid and water along with a resin monomer that allows light activation **[3]**. Composite resins valued for their tooth-coloured appearance and conservative preparation requirements, hence are routinely applied in both anterior and posterior restorations. Cention-N is a newer "alkasite" restorative material designed with specialized filler technology (partially functionalized by silanes) and monomer system intended to reduce polymerization shrinkage and associated stresses **[4]**. Discoloration of teeth is a cosmetic problem that is often the patient's primary concern. Although various restorative procedures are available but discoloration can often be corrected totally or partially by a more conservative approach *i.e.* bleaching, which is relatively a simple procedure to perform and less expensive. Dental bleaching relies on chemical agents that oxidize the organic pigments within enamel and dentin, resulting in a lighter tooth shade **[1]**. However interaction of this bleaching agent with restorative materials may lead to undesirable changes including discoloration of restorative material, compromised marginal adaptation and reduced durability of a restoration. There is very little literature which has shown the effect of bleaching agent on newer tooth coloured restorative materials like RMGIC, Cention N and Nanofilled Composite resin **[5, 6]**. Therefore, it is of interest to evaluate the effect of 35% hydrogen peroxide bleaching gel on microleakage of RMGIC, Cention N and nanofilled composite in standardized Class V restorations.

Materials and Methods:
The present study was approved by the institutional ethical committee with reference no 0629/A.D.C. & H/2021-22. Ninety single rooted freshly extracted human premolar teeth were selected in the present study. After cleaning and disinfection, standard class V cavities (3mm mesiodistal width, 2 mm occlusogingivally height & 2 mm pulpal depth) were prepared on the gingival third of buccal surface of all teeth. Then all samples (n=90) were randomly divided into 3 groups (n=30) based on the type of restorative materials used in the study *i.e.* Group-I: Teeth restored with RMGIC (Resin modified glass ionomer cement) (Fuji II LC , GC corporation, Japan), Group-II: Teeth restored with Cention N (Ivoclar, Vivadent AG, Liechtenstein) ,Group- III : Teeth restored with Filtek Z350XT (3M – ESPE) using Single Bond Universal Adhesive (3M – ESPE). Teeth were then restored according to the manufacturer´s instructions. Each group was then further sub divided into 2 subgroups A & B (n=15) based on the treatment with bleaching gel (35% hydrogen peroxide gel, FGM Whiteness HP Maxx). Samples of sub - group IA, IIA and IIIA were treated with bleaching gel to serve as experimental groups while the samples of group IB, IIB and IIIB were not treated with bleaching gel served as control groups. After that all samples were immersed in 0.5% basic fuchsin dye solution (Labogens, India) for 24 hours at room temperature. Each tooth was then sectioned longitudinally in buccolingual direction through the centre of the restorations using a diamond coated disc. Followed by microleakage analysis under stereomicroscope (Leica, Switzerland) at 10X magnification to determine the degree of dye penetration at the occlusal and gingival margins of the restoration. Raw data were then collected and subjected to

statistical analysis. Munro, Hilton and Hermesch scoring system **[2]** was used to score the microleakage.

[1] Score 0: No evidence of dye penetration.
[2] Score 1: Penetration of dye upto half of cavity wall.
[3] Score 2: Penetration of dye more than half of the cavity wall.
[4] Score 3: Penetration of dye involving axial wall.

Statistical analysis:
Statistical analysis was done using SPSS statistical software 20 version. The descriptive statistics were included mean and standard deviation. The intragroup comparison was done using paired t-test and intergroup analysis was done using independent t-test. The level of significance was set at P- value < 0.05.

Results:
Among all examined groups, Group III (nanofilled composite) showed the highest microleakage, followed by Group II (Cention N), while Group I (RMGIC) showed the least microleakage; the difference between Group I and Group II was not statistically significant (p>0.05). **Table 1** summarizes the comparative microleakage pattern across the experimental subgroups. Bleached subgroups showed greater leakage than their corresponding non-bleached controls, with the highest leakage observed in the bleached nanofilled-composite subgroup.

Table 1: Comparative microleakage pattern among experimental subgroups

Subgroup	Restorative material	Bleaching exposure	Reported microleakage interpretation
IA	RMGIC	Yes	Lowest among bleached groups; IA vs IIA not significant
IIA	Cention N	Yes	Intermediate; lower than nanofilled composite
IIIA	Filtek Z350XT	Yes	Highest among bleached groups
IB	RMGIC	No	Lowest overall; IB vs IIIB significant
IIB	Cention N	No	Intermediate; IB vs IIB not significant
IIIB	Filtek Z350XT	No	Highest among non-bleached groups

Discussion:
The primary goal of dental restorative material is to restore form, function and aesthetics. Restoration of class V cavities presents a special challenge to a clinician because the gingival margins of these class V cavities partly lies on enamel and partly either on dentin or on cementum **[7].** Compared to enamel, dentin is characterized by its tubular structure, greater organic composition and increased fluid content, all of which lowers its surface energy **[8]** and leads to a difficulty in achieving the adequate marginal seal and make the restoration prone to microleakage. Microleakage can further causes the hypersensitivity, secondary caries, pulpal inflammation, tooth discoloration and accelerated deterioration of the restorative material which ultimately leads to failure of a restoration **[9].** Hence class V cavity was chosen to evaluate microleakage in the present study. An effective restorative material should adhere well to the cavity walls in order to minimize microleakage. In this study, three commonly used restorative agents like Cention N, Resin-Modified Glass Ionomer Cement (RMGIC) and Filtek Z350XT (3M ESPE) were selected for restoring class V cavities **[10].** RMGIC is a hybrid material that integrates the benefits of traditional glass ionomer cements along with resin components, enabling it to harden through both an acid–base reaction and light-induced polymerization. This dual mechanism enhances its mechanical strength, esthetics, bonding ability and fluoride release compared to conventional GIC **[2]**. Cention N, on the other hand, is a relatively new restorative material based on urethane dimethacrylate (UDMA). It is primarily self-curing but also allows optional light activation. Nanofilled composites such as Filtek Z350XT contains a high proportion of filler particles with reduced particle size which helps to reduce polymerization shrinkage while improving their mechanical properties including tensile, compressive and fracture resistance **[7].** In modern dentistry, patient demand for whiter teeth has been increased considerably, making bleaching procedures a preferred minimally invasive option to enhance dental aesthetics. Although bleaching is effective in improving the appearance of stained teeth, its interaction with restorative materials may lead to undesirable changes, including discoloration of restorative materials **[12].** The degree of alteration depends largely on how deeply the bleaching agent penetrates the restorative substance, which can influence the important physical properties such as surface hardness and roughness **[9].** Given this background, the present study was aimed to assess the effect of a 35% hydrogen peroxide bleaching gel on the microleakage of various tooth-coloured restorative materials. For this purpose, FGM Whiteness HP Maxx was employed which contains 35% of hydrogen peroxide as an active ingredient. The whitening action of this material occurs when hydrogen peroxide decomposes and releases the free radicals that degrade pigmented carbon-based molecules within the tooth structure **[13].** These agents can enter either through marginal gap at the tooth – restoration interface or through inherent porosities of the restorative material, potentially contributing to microleakage and discolouration **[14]**. Dye penetration is one of the most frequently applied methods for assessing microleakage **[15].** A variety of dyes have been used for this purpose including methylene blue, basic fuchsin, India ink, silver nitrate, Rhodamine B and certain coloured inks such as procion brilliant blue. The selection of a suitable dye is generally depends on properties such as its molecular size, which should approximate that of bacteria and also its ability to produce a clear, high-contrast stain that can be visualized under a stereomicroscope for quantitative analysis of the tooth – restoration junction. Methylene blue, however, tends to dissolve during the clearing procedure and silver nitrate particles are smaller than bacterial dimensions, which limits their reliability. To overcome these limitations of Methylene blue, 0.5% basic fuchsin was employed in the present study, which is easy to use and a cost-effective option **[16].** The results of the present study

showed that nanofilled composite resin treated with bleaching gel showed the highest microleakage while RMGIC without bleaching gel treatment showed the least microleakage. Reason behind the less microleakage in RMGIC is due to its chemical adhesion and hybridization. In the present study Cention N showed less microleakage as compare to flowable composite in both enamel and dentin margins but there was no significant differences were noticed. The less microleakage of Cention N could be attributed to lesser degree of polymerization shrinkage due to the patented filler technology *i.e.* Isofiller, its organic / inorganic ratio and also to the monomer composition. This reduces the shrinkage stress and also minimizes the shrinkage forces during polymerization and also expands slightly as forces increases during polymerization **[17].** The limitation of the present study is that it is an *in vitro* study; hence the results can vary in *in vivo* or *ex vivo* oral conditions. In an *in vitro* study, oral condition simulation of temperature and moisture cannot be maintained, which differs from the restorative material performance **[18]**. Hence an extensive clinical research with different oral conditions is needed to determine the microleakage of different restorative material after tooth bleaching. Comparative microleakage findings for glass-ionomer-based Class V restorations further support inclusion of RMGIC as a reference material **[11]**.

Conclusion:

Nanofilled composite resins treated with bleaching gel showed highest microleakage while RMGIC without treatment with bleaching gel showed least microleakage and the difference was statistically significant. RMGIC showed less microleakage as compared to Cention N, but difference is not statistically significant. On comparing Cention N and nanofilled composite, Cention N showed less microleakage and the difference is statistically significant.

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Conflicts of interest: There are no conflicts of interest

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