Comparative evaluation of microleakage of newer generation dentin bonding agents: An in vitro study

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ABSTRACT

Context: Adhesive dentistry has been progressing with rapid pace over the past decade. Composite resin is the most esthetic restorative material currently available for restoring teeth. In spite of it being in use since a decade, still failure cases are seen which are mainly due to polymerization shrinkage and subsequent inadequate adhesion to cavity walls, leading to microleakage. Various generations of dentin bonding agents have been introduced to overcome the shortcoming of composite resin.

Aims: To determine the microleakage of the 6th, 7th, and 8th generation dentin bonding agents.

Materials and Methods: Forty-five extracted human premolars were taken for the study. Standardized Class V cavities were prepared on all the teeth. The samples were divided into three groups according to the generation of bonding agent used. Group I was bonded with the 6th generation, Group II with the 7th generation, and Group III with the 8th generation dentin bonding agent. All the Class V preparations were restored with a nano-ceramic composite restorative (Ceram X). The samples were then thermocycled between 5 and 55 ± 2°C for 100 cycles and immersed in 2% methylene blue for 48 h for evaluation of microleakage under a stereomicroscope.

Statistical Analysis Used: The data was statistically analyzed using Kruskal–Wallis nonparametric analysis, and Mann–Whitney U-test was applied to compare the various groups.

Results: The microleakage value was the highest in Group II (7th generation bonding agent) followed by Group I (6th generation bonding agent) and least in Group III (8th generation bonding agent).

Conclusions: The 8th generation dentin bonding showed statistically significant results in terms of lesser microleakage as compared to the 6th and 7th generation dentin bonding agents.

Key words: Bonding agents, eighth generation dentin bonding agent, microleakage

As we enter the new millennium, we find a meteoric rise in the use of bonded composite restorations with immense success. In the beginning of the era of restorative dentistry, retention and stabilization of restoration often required the removal of sound tooth structure to provide large undercuts to gain auxiliary retention aids. This problem is greatly solved with the introduction of newer bonding systems in adhesive dentistry. [1]

Evolution began by Castan in 1938 and has reached a hallmark of self-etching systems. Self-etching adhesives came to be known as “6th generation dentin bonding agents.” Noteworthy feature was the use of acidic adhesives giving us an advantage of eliminating the acid etching step. Apart from simplification of three-step to two-step application, the rationale behind this system was to superficially demineralize dentin and simultaneously penetrate it with monomers, which could be polymerized in situ. Although the bond to the dentin remains strong

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enough (23 MPa), the multiple components and multiple steps in the technique could cause confusion and led to error.\(^2\)

Currently, “7th generation self-etch systems” combine an etchant, primer, and adhesive in one container compared to total-etch or etch and rinse systems, whereby separate etchant, primer, and adhesive monomers are utilized. The 7th generation dentin bonding agents are called as self-etching or all in one adhesive which required no mixing. Thus, they were time-saving.\(^2,3\)

Further, modification was achieved by introducing light- and self-cured bonding agent called as the “8th generation dentin bonding agent.” It worked both in self- and light-cure mode. It was new single dose delivery system and prevents solvent evaporation, a common problem in a variety of other bonding systems. It ensured an immediate stick effect which guaranteed that the bond will not be blown out of the cavity while air drying. This resulted in a superior marginal integrity and protection against dentinal sensitivities.

The longevity of a restoration requires a good marginal seal, strength of material, etc., Microleakage has been recognized as the major clinical problem with composite restorations.\(^4\)

Thus, this study was aimed to determine the microleakage of the 6th, 7th, and 8th generation dentin bonding agents.

**MATERIALS AND METHODS**

The present in vitro study was carried out in the Department of Pedodontics and Preventive Dentistry, D.J. College of Dental Sciences and Research, Modinagar, in collaboration with Subharti Dental College, Meerut.

**Preparation of samples**

Forty-five teeth extracted for orthodontic or periodontal reasons were used in the study. Teeth were cleaned of debris using ultrasonic scaler and autoclaved. Class V cavities (3 mm x 2 mm x 1.5 mm) were prepared on the buccal/lingual surfaces of teeth, with a high-speed airotor. Dimensions were standardized using Vernier caliper. The prepared cavity was rinsed thoroughly with air/water spray and dried.

**Division of samples**

The collected 45 samples were randomly divided into the following three groups and color coded accordingly. Group I - (red) samples were bonded with FL Bond II (6th generation dentin bonding agent), Group II - (blue) samples were bonded with Xeno V (7th generation dentin bonding agent), and Group III - (green) samples were bonded with Futurabond DC (8th generation dentin bonding agent) [Flowchart 1].

**Application of bonding agent**

Bonding agents were applied in all the experimental groups (Groups I–III) according to the manufacturer’s instructions.

**Group I**

Sample teeth in this group were bonded with FL Bond II (6th generation, giomer self-etching, light-cured dentin bonding agent). First, the primer was applied thoroughly on the prepared cavity for 5 s, left undisturbed for 10 s, and dried with air for 5 s. An even layer of bonding agent was then applied with an applicator tip on the entire surface for 5 s then light cured for 10 s.

**Group II**

Sample teeth in this group were bonded with Xeno V (7th generation, self-etching, light-cured dental adhesive). It was supplied as an easy squeeze bottle. With an applicator tip, one coat of the bonding agent was applied on the prepared cavity, left undisturbed for 20 s, dried with air for 5 s, and was then light cured for another 20 s.

**Group III**

Sample teeth in this group were bonded with Futurabond DC (8th generation, self-etching, dual-cured dental adhesive). It was supplied as a two-bottle system. One drop of Liquid A and one drop of Liquid B was dispensed and mixed with an applicator tip, well for 5 s. It was then applied with the same applicator tip onto the prepared cavity with a rubbing motion for 15 s, gently air dried for 5 s, and then light cured for 20 s.

**Restoration of samples**

All the Class V preparations were restored with a nano-ceramic composite restorative (Ceram X) in three increments. The composite restorations were then finished using a super snap kit.

**Thermocycling and dye immersion**

The prepared samples were subjected to thermocycling in water baths for 500 times between 5° and 55° with a dwell time of 30 s in each bath and a transfer time of 30 s to simulate the oral conditions. After thermocycling, the apices of teeth were sealed with sticky wax. All tooth surfaces were triple coated with finger nail varnish, except a 0.5–1.0 mm

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**Flowchart 1: Division of samples**

- **Group I (Red)**
  - n=15
  - FL Bond II (Experimental Group I)

- **Group II (Blue)**
  - n=15
  - Xeno V (Experimental Group II)

- **Group III (Green)**
  - n=15
  - Futurabond DC (Experimental Group III)
window around the restoration margins. The teeth were immersed in 2% methylene blue for 48 h after which they were rinsed with water and air-dried.

Sectioning of samples and microleakage evaluation
All the samples were longitudinally sectioned in a buccolingual direction using a diamond disc at slow speed in a micromotor straight handpiece. The microleakage was assessed by viewing all the treatment groups under a stereomicroscope at a magnification of × 40, and the scoring criteria for the microleakage assessment were followed according to Vinay and Shivanna:[5] 0 = no dye penetration, 1 = dye penetration up to one-third cavity depth, 2 = dye penetration up to two-third cavity depth, 3 = dye penetration to full depth of cavity and 4 = dye penetration onto axial wall of cavity [Figure 1].

RESULTS
The data were subjected to statistical analysis using SPSS version 19. The \( P < 0.05 \) is considered statistically significant and Kruskal–Wallis nonparametric analysis and Mann–Whitney U-test were applied to compare the various groups.

Table 1 shows the mean value of microleakage and it was found to be 1.73 ± 0.799 for Group I, 2.00 ± 0.655 for Group II, and 0.87 ± 0.640 for Group III. It was noted that microleakage value was the highest in Group II (7th generation bonding agent) followed by Group I (6th generation bonding agent) and the least in Group III (8th generation bonding agent). When intercomparison between various groups was done, significant difference was found between Group I and Group III and Group II and Group III with a \( P \) value of 0.004 and 0.000, respectively. Nonsignificant difference was found between Group I and Group II with \( P \) value of 0.366 [Table 2 and Graph 1].

DISCUSSION
The advent of dentin bonding agents, with its property of adherence to the tooth structure by both micromechanical and chemical means, heralded a new era in the field of dentistry. In 1938, Castan developed a new epoxy molecule that sparked the search for dentin bonding agents. Bunocore (1956) pioneered the work on adhesion to dentin, since then different generations of dentin bonding agents have been evolved with the 8th generation bonding agent as the latest family member.[6,7]

A prime feature of dental restorative materials is its marginal integrity, along the tooth–restorative interface. An incompetent marginal integrity causes gaps in the tooth restoration interface leading to microleakage. Microleakage presented as a major clinical problem as it causes secondary caries, tooth discoloration, staining of restorative margins, adverse pulpal response, and even hasten the fracture of composite restorations.[8]

Table 1: Mean values of microleakage in Group I, Group II, and Group III

| Groups* | n  | Mean ± SD | Median | SEM |
|---------|----|-----------|--------|-----|
| I       | 15 | 1.73 ± 0.799 | 2.00   | 0.206 |
| II      | 15 | 2.00 ± 0.655  | 2.00   | 0.169 |
| III     | 15 | 0.87 ± 0.640  | 1.00   | 0.165 |

*Group I - 6th generation bonding agent, Group II -7th generation bonding agent, Group III - 8th generation bonding agent. SD=Standard deviation, SEM=Standard error of mean

Table 2: Intergroup comparison of the mean rank of microleakage in Group I, Group II, and Group III

| Group | n  | Mean rank | Mann–Whitney U-test | \( P \) |
|-------|----|-----------|---------------------|-------|
| I     | 15 | 14.20     | 93.000              | 0.366 |
| II    | 15 | 16.80     | 16.000              | 0.004 |
| I     | 15 | 19.87     | 47.000              | 0.000 |
| III   | 15 | 9.90      | 28.500              | 0.000 |

*The mean difference is significant at the 0.05 level. Group I - 6th generation bonding agent, Group II-7th generation bonding agent, Group III - 8th generation bonding agent

Figure 1: Score criteria[5]
Various advancements in the properties of adhesive systems have been developed to reduce microleakage by strengthening the adhesion between the tooth surface and the restoration, such as increasing the acid potential of the etchant, addition of nanofillers, and change in resin composition.\\[9\\]

In the present study, the microleakage of three different generations namely 6th generation, 7th generation, and 8th generation was compared and it was seen that the 8th generation dentin bonding agent (Futurabond DC) showed the least microleakage when compared to the 6th generation (Fl Bond II) and the 7th generation (Xeno V) dentin bonding agent which is in accordance to the studies done by Joseph et al.\\[10\\] and Kambale et al. (2014)\\[11\\] that concluded 8th generation dentin bonding agent showed better bond strength to 6th and 7th generation dentin bonding agents.

The 8th generation dentin bonding agent (Futurabond DC) contains polyfunctional adhesive monomers (phosphoric acid modified methacrylate esters). These acid esters, when mixed with water, produced a favorable lower pH value of 1.4 as in comparison to unfavorable higher pH value of 1.8 and 2.4 of the 7th and 6th generation dentin bonding agents, respectively. The lower pH favors complete removal of smear layer and the hydroxyapatite is dissolved (demineralized), creating a deeper retentive pattern on the tooth surface. Moreover, the 8th generation dentin bonding agent (Futurabond DC) is a nanofilled adhesive which forms a thicker adhesive layer and a more flexible interface, which may help to counteract stress resulting from polymerization shrinkage of the resin composite.\\[12\\]

The maximum microleakage of the 7th generation dentin bonding agent (Xeno V), which is HEMA-free, in comparison with the 6th generation dentin bonding agent (Fl Bond II) and 8th generation dentin bonding agent (Futurabond DC) could be contributed to the absence of HEMA. As stated by Pashley et al.,\\[13\\] the hydrophilicity of HEMA makes it an excellent adhesion promoting monomer and by enhancing wetting of dentin it significantly improves bond strength, thereby reducing microleakage.\\[14\\] HEMA also generates hydrogen bonds inside the microporosities of demineralized dentin, mechanically interlocking into the substrate by undergoing hygroscopic expansion after polymerization, thereby resulting in stronger bonds to the dentin surface.\\[15\\] In the 7th generation dentin bonding agent instead of HEMA, the water content was increased in an effort to improve its bonding efficacy and reduce microleakage; however, instead of improving its bonding efficacy, it got reduced as in the absence of HEMA the collagen peptides forms intermolecular hydrogen bonds with the nearest neighboring collagen peptides which may contribute to the collapse of the collagen network, thereby leading to weaker bonds and higher microleakage.\\[14\\]

In the 6th generation (Fl Bond II) dentin bonding agent, microleakage was more than the 8th generation (Futurabond DC) dentin bonding agent. The possible reason for this could be the higher pH (2.4) of the 6th generation dentin bonding agents in comparison to the 8th generation dentin bonding agent (pH - 1.4). Because of higher pH value, modification of the smear layer is achieved in contrast to the complete removal of smear layer as evident with the use of 8th generation dentin bonding agent. The removal of smear layer is essential as it interferes with the process of bonding of the composite resin because of its composition which consists of partly denatured collagen and mineral.\\[16\\]

However, the 6th generation dentin bonding agent showed less microleakage when compared with 7th generation dentin bonding agent (Xeno V) analogous to the results of the study conducted by Deliperi et al.,\\[17\\] which concluded that 7th generation showed maximum microleakage as compared to 5th and 6th generation.

The reason for this could be the presence of HEMA. The higher bond strength and lower microleakage following HEMA may be due to the fact that the demineralized collagen is kept wet and does not collapse, whereas in case of 7th generation dentin bonding agent, the HEMA is replaced by water which causes the microporosities to be filled with water thereby preventing the resin penetration. Further, the wettability enhanced by HEMA may permit a porous collagen network, which permits greater infiltration of adhesive monomers than do surfaces that are over hydrated due to the increased water content of the bonding agent.\\[13\\] Thereby, resulting in mechanical interlocking of resin in the dentin substrate, stronger bonds to the dentin surface and thus lesser microleakage at the restoration dentin interface.

**CONCLUSIONS**

Based on the result of the present study, the 8th generation dentin bonding agent presents a better marginal integrity in comparison to the 6th and 7th generation dentin bonding agents. We recommend further studies to authenticate these results. Clinical trials should be made so as to check its bonding efficacy in the intraoral environment.

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**Conflicts of interest**

There are no conflicts of interest.

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