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Original Article

Influence of Simulated Hyperbaric Condition on the Dentin – Composite Resin Interface of Bulkfill and Flowable Composite Resins with Different Adhesive Systems – An *In vitro* Study

S Anitha Rao, V Chandrasekhar, M Sandeep, Shaik Sana, V Aravind Reddy

Department of Conservative Dentistry and Endodontics, Mamata Dental College, Khammam, Telangana, India

Abstract

Background: Dental composites are complex, tooth-colored filling materials composed of synthetic polymers, particulate ceramic reinforcing fillers, and molecules which promote or modify the polymerization reaction. Dental adhesives are solutions of resin monomers that join a restorative material with a dental substrate after the monomers set by polymerization. The integrity and durability of the marginal seal are essential for any restorative system to maintain pulpal health and to increase the longevity of the restoration. Inability to seal the gingival margins of Class II restorations has always been a displeasing and lasting obstacle. These areas are critical to the bonding process because of minimal or total absence of enamel.

Aim: The present study aims to evaluate the influence of simulated hyperbaric condition on the dentin-composite resin interface of bulk fill and flowable composite resins with different adhesive systems.

Materials and Methods: In this study, 40 extracted maxillary and mandibular molar teeth were selected. Class II mesial and distal cavity preparations were prepared and restored with bulk fill composite and 20 teeth were restored with flowable composite. Among these, half the cavities were restored by Total-Etch and remaining half were restored by Self-Etch (SE) protocol. Among forty teeth, 20 teeth were treated under hyperbaric conditions and remaining 20 teeth were treated under ambient pressure. Specimens were immersed in 2% methylene blue dye for 24 h and were rinsed under tap water for 30 min. The dye penetration was measured at occlusal and gingival margins of each section by using a calibrated stereomicroscope at ×20 magnification.

Results: The results obtained were statistically analyzed for all the groups.

Conclusion: Within the limitations of the study, it can be concluded that under-stimulated hyperbaric pressure, bulk fill composites showed higher microleakage when compared to the flowable composites. Total-Etch adhesives showed higher microleakage when compared to the SE adhesives.

Key words: Bulk fill composite, Flowable composite, Hyperbaric oxygen, Self-etch adhesive, Stereomicroscope

INTRODUCTION

Dental composites are complex, tooth-colored filling materials composed of synthetic polymers, particulate ceramic reinforcing fillers, and molecules which promote or modify the polymerization reaction that produces the cross-linked polymer matrix from the dimethacrylate resin monomers, and silane coupling agents which bond the reinforcing fillers to the polymer matrix.[1]

These resin composites are widely used in the restoration of posterior teeth due to increasing demand for aesthetics as there is improvement in newer generation bonding agents and resin composite formulations.[2,3]

The use of tooth-colored restorative material requires the meticulous use of an adhesive technique.[4] Newer materials and techniques, as well as new methods of analysis and

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Corresponding Author: S Anitha Rao, Department of Conservative Dentistry and Endodontics, Mamata Dental College, Khammam - 507 002, Telangana, India.

diagnosis, may eventually offer the opportunity to eliminate marginal leakage around dental restorations.[5]

One of the major changes in resin-based composite technology was the introduction of bulk fill resin composites ensuring adequate depth of cure.[6]

Solare Sculpt, an universal sculptable composite with advanced light scattering technology that merges GC's innovative single dispersion nano-fillers. Sculpt has unique homogenous, pre-polymerised nano-fillers with high density and uniform dispersion silane treatment technology. It consists of 300-nanometer strontium glass fillers homogeneously dispersed for high flexural strength and wear resistance.[7]

The first generation of flowable composite resins was introduced to the dental profession in late 1996.[8] The content of inorganic filler is lower to improve handling properties.[9] G-aenial Universal Flo is a universal injectable composite which features 200 nano metrestrontium glass fillers homogeneously dispersed for high flexural strength and wear resistance.[10]

Dental adhesives are solutions of resin monomers that join a restorative material with a dental substrate after the monomers set by polymerization.[11] Resin-based adhesive systems can be classified in either the Etch-And-Rinse (ER) systems or the Self-Etch (SE) systems. The simplified two-step version combines the second and third steps but still follows a separate "Etch and Rinse" phase.[11]

SE adhesives use non-rinse acidic monomers that simultaneously condition and prime the dentin, this approach eliminates the rinsing phase, lessens the clinical application time, and reduces the technique-sensitivity.[12]

Barodontalgia is defined as dental pain caused by pressure variations of the environment Barodontagia occurs at an altitude of approximately 3000 m (0.75 atmosphere) and in the diver at 10 m 1 (atmosphere).[13,14] The normal ambient atmospheric pressure is measured as 1. Each additional increment of pressure over 1 atmosphere is equal to 33 ft of depth of sea water.[15]

Microleakage is defined as the clinically undetectable passage of bacteria and bacterial products, fluids, molecules, or ions from the oral environment along the various gaps present in the cavity restoration interface. Microleakage can lead to post-operative pain, recurrent caries, pulpal damage, and marginal discoloration.[16]

The marginal integrity of composite restoration refers to its marginal fit and marginal adaptation thereby increasing the longevity of the restorative material.[17] Inability to seal the gingival margins of Class II restorations has always been a displeasing and lasting obstacle. These areas are critical to the bonding process because of minimal or total absence of enamel. Hence, there is a constant search for the material and technique that ensures adhesion to the tooth structure to minimize the leakage potential.[18]

The aim of the present study is to evaluate the influence of simulated hyperbaric condition on the dentin-composite resin interface of Bulk fill and Flowable composite resins with different adhesive systems.

MATERIALS AND METHODS

Sample Selection

Teeth with no visible caries, previous restorations, fracture lines, or cracks were included in the study and carious teeth, previously restored teeth, and teeth with fracture lines and cracks were excluded from the study. A total of 40 human maxillary and mandibular molar teeth were selected for the study [Figure 1]. Teeth were gently cleaned with tap water and stored in 1% chloramine solution at 4°C for up to 1 month.

Cavity Preparation

Class I mesial and distal cavities of standardized dimensions 4 mm bucco-lingual width, 2 mm mesial depth, 2 mm distal depth with the gingival cavosurface margin located 1 mm above the cemento-enamel junction (CEJ) [Figure 2] were prepared on each tooth using #245 carbide bur and air rotor handpiece to obtain 80 cavities. Cavity dimensions were measured with William's probe and digital caliper.

Restorative Procedure

A Tofflemire retainer and matrix band were placed, 20 molars were restored with bulk fill composite, and 20 molars were

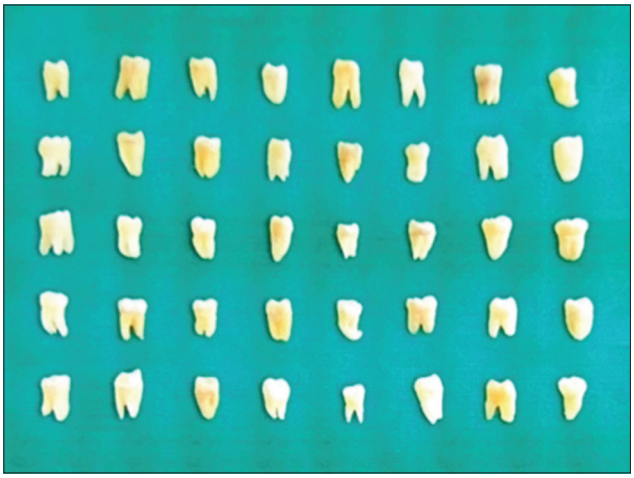


Figure 1: Extracted maxillary and mandibular molar teeth

restored with flowable composite [Figures 3 and 4]. Among these, half the cavities were restored with Total-Etch protocol and remaining half were restored with SE protocol.

Group Distribution of Experimental Environment

Twenty teeth (40 cavities) were restored with Bulk fill and 20 teeth (40 cavities) were restored with flowable composites with SE and Total-Etch protocol. These specimens were stored in an incubator at 37°C for 24 h. Among these 20 teeth (40 cavities) were treated under stimulated hyperbaric conditions. The hyperbaric condition involves placing samples in a cylinder that simulate advice in the hyperbaric oxygen chamber. The remaining 20 teeth (40 cavities) were treated under ambient pressure.

Bulkfill Composites

A1: Hyperbaric condition with SE universal adhesive. (n = 10)
A2: Ambient pressure with SE universal adhesive. (n = 10)
A3: Hyperbaric condition with Total-Etch universal adhesive. (n = 10)
A4: Ambient pressure with Total-Etch universal adhesive. (n = 10)

Flowable Composites

B1: Hyperbaric condition with SE universal adhesive (n = 10).
B2: Ambient pressure with SE universal adhesive (n = 10).
B3: Hyperbaric condition with Total-Etch universal adhesive (n = 10).
B4: Ambient pressure with Total-Etch universal adhesive (n = 10).

For groups Al, A2, B1, and B2, after Class I cavity preparation, Tofflemire retainer and matrix band was placed around each tooth. SE universal adhesive (Ivoclar Tetric N-Bond Universal) was applied, air sprayed for 3–5 s, and cured for 20 s with LED curing unit. A2 shade bulkfil composite (GC SOLARE Sculpt) and A2 shade Flowable composite GC (G-aenial Universal Flo) was placed into the cavities with Teflon-coated instrument and cured for 20 s from the occlusal surface. Tofflemire retainer and matrix band were then removed, and the restorations were cured for another 20 s from the buccal and lingual surfaces.

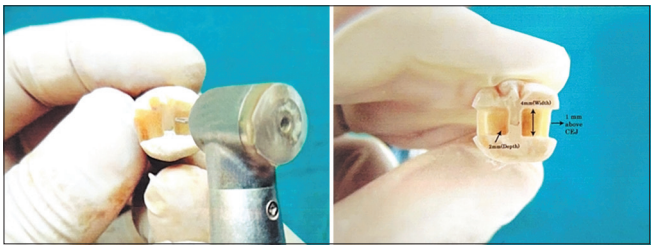


Figure 2: Cavity preparation

For groups A3, A4, B3, and B4, after Class I cavity preparation, Tofflemire retainer, and matrix band was placed around each tooth. Etchant (Eco-Etch Ivoclar) was applied on the enamel for 30 s and on dentin for 15 s with an applicator tip. They were rinsed with air and water spray for 10 s and dried with cotton pellet. Total-Etch universal adhesive (Ivoclar Tetric N-Bond) was applied, air sprayed for 3–5 s, and cured for 20 s with LED curing unit. A2 shade bulk fill composite (GC SOLARE Sculpt) and A2 shade flowable composite (GC G-aenial Universal Flo) was into the cavities with Teflon coated instrument and cured for 20 s from the occlusal surface. Tofflemire retainer and matrix band were then removed and the restorations were cured for another 20 s from the buccal and lingual surfaces.

The restoration surfaces of all the samples were polished using Sof-Lex3M (ESPE) polishing discs and incubated at 37°C for 24 h. Among them, 20 teeth (40 cavities) were subjected to stimulate hyperbaric pressure at 5 bars of oxygen for 30 min [Figure 5].

Dye Penetration

The external surface of each sample was completely coated with two layers of nail varnish, except for a 1 mm wide margin around the interface restoration left free. Specimens were immersed in 2% methylene blue dye for 24 h. Then, they were rinsed under tap water for 30 min. The specimens were embedded in methylmethacrylate acrylic resin and each sample tooth was sectioned with a diamond disc along the mesio-distal direction, coincident with the center of the restoration. The dye penetration was measured at occlusal and gingival margins of each section by using a calibrated stereomicroscope at ×20 magnification. The data obtained were tabulated and analyzed statistically.

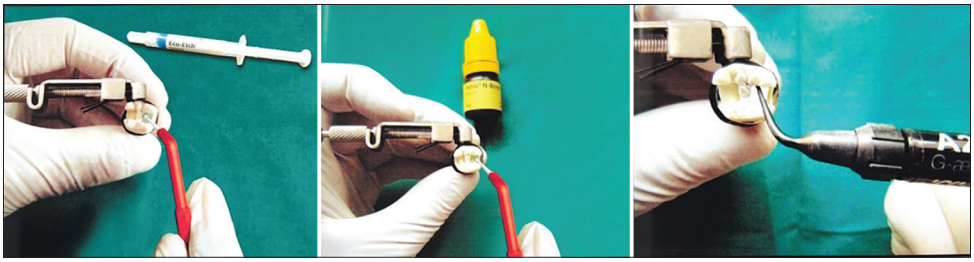


Figure 3: Restoration of samples with flowable composite

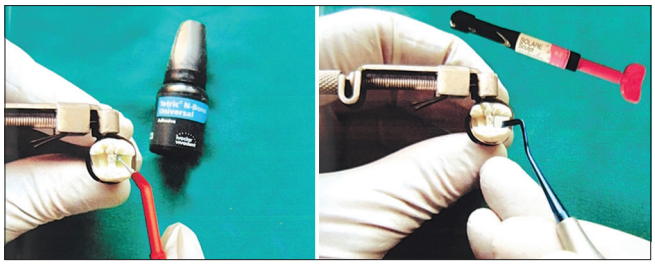


Figure 4: Restoration of samples with bulk fill composite

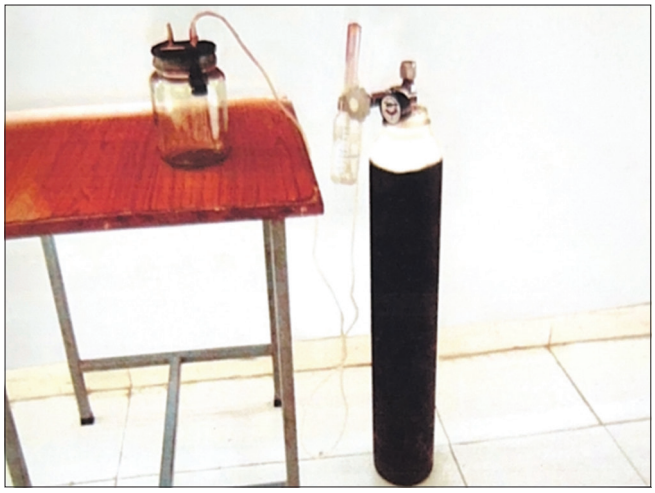


Figure 5: (Hyperbaric cylinder)

Statistical Analysis

Data were documented in Excel (Microsoft Excel 2010) and analyzed using SPSS (IBMSPSS Statistics for Windows version 20).

ANOVA test for association test was applied.

The statistical significance was set at 5% level ($P < 0.05$) and considered significant.

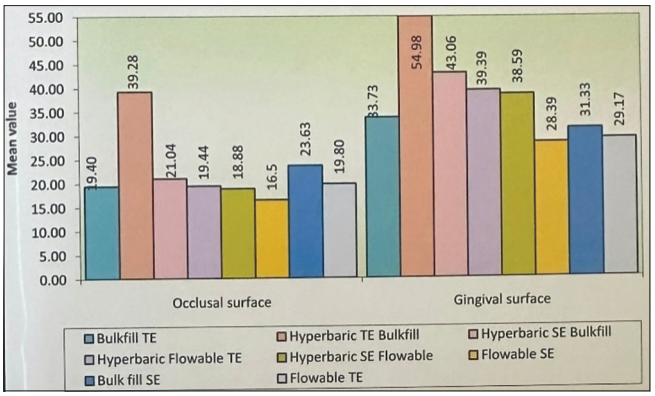
RESULTS

Graph 1 and 3 shows a greater percentage of microleakage in the Bulk fill Total-Etch composites under hyperbaric condition when compared to the other groups.

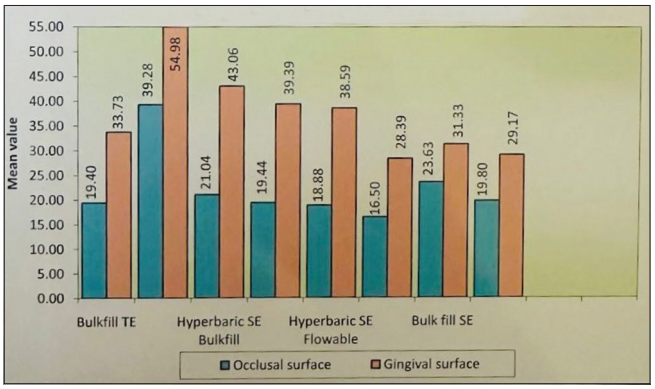
Graph 3 shows a greater percentage of microleakage in the gingival surfaces when compared to the occlusal surfaces in each group.

A greater percentage of microleakage in the bulk fill Total-Etch composites under hyperbaric condition when compared to the other groups.

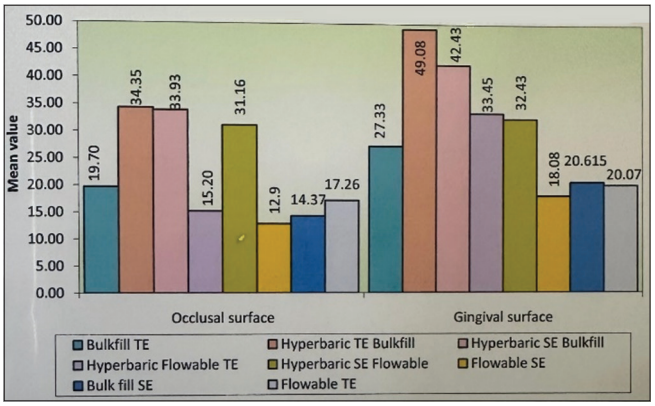
A greater percentage of microleakage in the gingival surfaces when compared to the occlusal forces in each group [Graph 2 and Figures 6-9].



Graph 1: Comparison of eight groups with % of microleakage in occlusal and gingival surfaces in mesial side



Graph 2: Comparison of eight groups with % of microleakage in occlusal and gingival surfaces in distal side



Graph 3: Comparison of eight groups with % of microleakage in occlusal and gingival surfaces in distal side

DISCUSSION

Composite resin is a tooth-colored material and commonly used for esthetic restoration of anterior and posterior teeth. These are polymer matrix filled, tooth-colored restorative materials that derive their physical properties and handling characteristics from loading with reinforcing filler particles and the viscosity of the resin matrix.[19]

Figure 6: Hyperbaric bulk fill total etch

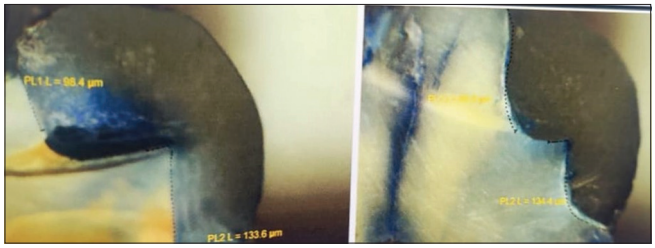


Figure 7: Hyperbaric bulk fill self-etch

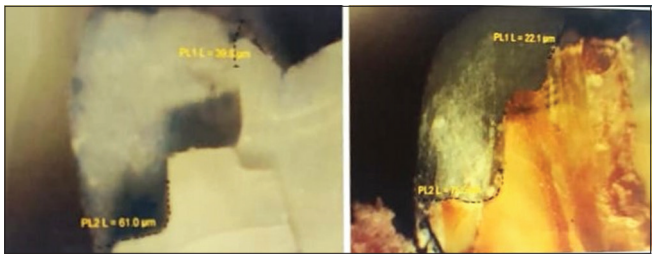


Figure 8: Hyperbaric flowable total etch

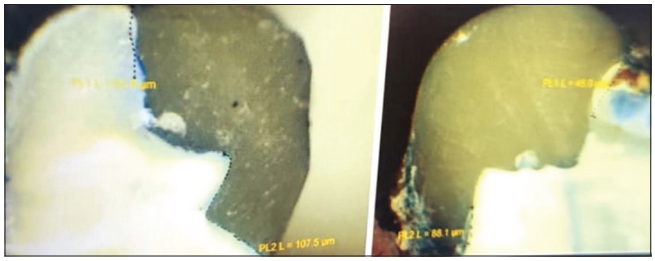


Figure 9: Hyperbaric flowable self-etch

Composite resins are considered the material of choice in restorative dentistry because of the increasing demand for high-quality esthetic results in everyday practice due to increasing demand for esthetics as well as dramatic improvement in newer generation bonding agents and resin composite formulations.[20] Major changes in resin-based composite technology was the introduction of bulk fill resin composites.[6] Bulk fill resin composites are available in both flowable and conventional or sculptable viscosities, with the premise of simplified application, while still ensuring adequate depth of cure. These restorative materials are highly technique sensitive, particularly in Class II restorations; it is difficult to achieve a strong bond between the high-viscosity composite resins and cavity walls, especially the gingival floor.[21] Therefore, first generation of flowable composite resins was introduced in 1996.[8]

Tetric N-Bond adhesive contains Bis-phenol A glycidyl metha crylate,urethanedimethacrylate, dimethacrylate, hydroxyethyl methacrylate, phosphoric acid acrylate, nano fillers (SiO_2), ethanol, initiators, and stabilizers.[22] Tetric N-Bond Universal adhesive contains hydroxyl ethyl methacrylate, 10-Methacryloyoxydecyl dihydrogen phosphate, Methacrylated carboxylic acid polymer, Bis-phenol A glycidyl methacrylate, decandiol dimethacrylate, N,N-dimethyl aminoethyl methacrylate, camphorquinone, ethanol, water, and highly dispersed silicon dioxide having a Ph of 2.5.[23]

In this study, we evaluated the impact of a simulated hyperbaric environment on micro leakage of the dentin – composite resin interface of bulk fill and flowable composites with different adhesive systems.

In the present study, molar teeth were selected as they are most likely to be restored. Teeth were stored for 30 days in 1% chloramine solution as it has been recommended as infection controlling for research purposes and it does not show adverse effect on organic phase of denti.[24] Class II cavities were selected for the study because branching of tubules is numerous in the root dentin area and acid etching of this heterogeneous dentin surface is quite difficult.[25]

All the restored tooth samples were placed in an incubator at 37°C and 100% humidity for 24 h. Among them, 20 teeth were placed in a simulated hyperbaric oxygen chamber and a pressure of 5 bars of oxygen was released to simulate hyperbaric pressure of a diving condition for 30 min. The remaining 20 teeth were treated under ambient pressure.

The external surface of each tooth was completely coated with two layers of nail varnish, except a 1mm wide margin around the interface restoration left free to allow the leakage-tracing agent to contact the margins of the restoration.[26]

Dye penetration testing was chosen in the study because it was one of the oldest and most frequently used methods for the study of microleakage around restorations. Eosin, methylene blue, methyl violet, hematoxylin and mercuric chloride, prontosil soluble red, aniline dye, basic fuchsin, chromotrope 2R, crystal violet, and fluorescent dye (fluorescein), fluorescent dyes were found to be particularly useful as tracers for the demonstration of leakage around dental restorations.[27]

Although many methods can be used to evaluate microleakage at the interface of restorative materials and

tooth structure, dye, and radioisotope techniques appear to be the most popular.[28]

In the present study, 2% methylene blue was used for dye penetration as it was simple, inexpensive, and does not require complex laboratory procedures. It provides easy visualization of the prepared cavity in the digital images, providing the evaluators with a clear reference point from which to score and the dye also provides an excellent contrast with the surrounding environment.[29]

The dye penetration was measured at the dentin-composite resin interface by using a calibrated stereomicroscope with ×20 magnification connected to a camera and analyzed using software as it provides well magnified two-dimensional view showing the areas of microleakage.[25] The percentage of microleakage was determined by the measured length of the dye penetration divided by the measured length of the interface. The mean percentage microleakage was the mean of five specimens for each group investigated.[30]

In the present study, flowable composites showed lower microleakage when compared to the bulk fill composites. The possible reasons for less microleakage could be due to: (a) G-aenial Universal Flo contains a new silane surface treated ultra-fine strontium glass fillers with an average 200-nanometer size, which provides improved bonding between the particles and the matrix, thereby minimizing shrinkage. (b) High flexibility-G-aenial Universal Flo has a lower modulus of elasticity which helps the material to withstand masticatory forces and helps to reduce the marginal discrepancies of the tooth restorative interface. (c) Low volumetric shrinkage helps to conserve tooth structure by preserving the margins thereby minimizing the microleakage and cracks.[10]

In the present study, SE adhesive showed minimum microleakage (18.8 um) when compared to the Total-Etch adhesive system (38.8 um). This finding was in accordance with the study done by Saraswathi *et al.*[31]

In the present study, composite restorations under hyperbaric pressure conditions showed higher microleakage (187.9 m) when compared to those under ambient pressure due to expansion of gas within or near a defective tooth.

The present study showed a greater percentage of microleakage in the bulk fill composite, Total-Etch adhesives under hyperbaric condition (136.2 um) when compared to the other groups. This was similar to the study done by Sadeghi.[32]

The present study showed that microleakage at gingival margin (136.2 m) was significantly more when compared to the occlusal restorations (57.8 m). It was similar to the study done by Khamverdi *et al.* It could be due to better and stronger enamel bond in occlusal restoration because the enamel has an inorganic and homogenous structure.[33]

Limitations

The following limitations can be drawn from the present study:

1. Extracted human molars for the study. Selection of other teeth may vary the results.
2. Teeth restored with composites were subjected to simulate hyperbaric environment. These results may vary when applied to the clinical scenario.

CONCLUSION

Under stimulated hyperbaric condition:

1. Bulk fill composites showed higher microleakage when compared to the flowable composites.
2. Total-Etch adhesives showed higher microleakage when compared to the SE adhesives.

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