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Comparative Evaluation of Microleakage Of Three Newer Composite Resins Using SEM And Stereomicroscopy: An *In-Vitro* Study.

Shweta Tekriwal, Aniket Kumar, B Rajkumar, Vishesh Gupta, and Akanksha Bhatt*.

Department of Conservative Dentistry &Endodontics, BabuBanarasi Das College of Dental Sciences, Babu Banarasi Das University, Lucknow, India.

ABSTRACT

To evaluate and compare the microleakage in three different types of newer direct composite resins using Scanning Electron Microscopy and Stereomicroscopy. Class V cavities were prepared on 60 human mandibular premolar teeth. Teeth were then equally divided into 3 groups of 20 samples each. Group Iwas restored with everX Posterior using G-Bond (GC Japan), Group II with Smart Dentin Replacement using xeno V(Dentsply, Switzerland) and Group III with SonicFill using Optibond(Kerr Corporation, USA). After polishing the restorations, the specimens were immersed inmethylene blue dye for 24 hrs. The teeth were then sectioned longitudinally and observed for the microgaps and extent of microleakage under Scanning Electron Microscope and Stereomicroscope. Statistical analysis was done using ANOVA and Tukey test. Statistically no significant difference was found in the microleakage of SDR (group II) and Sonic Fill (group III) but there was statistically significant difference between the microleakage of everX Posterior (group I) and two other groups i.e SDR and SonicFill composite resins. None of the materials tested was able to completely eliminate the microleakage in class V cavities.

Keywords: Dye Penetration, everX Posterior, Microleakage, Microgaps, SEM, SDR,Sonicfill, Stereomicroscope

**Corresponding author*

INTRODUCTION

Dental composite resins have become the most popular direct restorative material in clinical dentistry today. Their main advantages include aesthetics and capability of forming a relatively stronger micromechanical bond to tooth structure.

Like all other dental materials, composites are also not devoid of limitations, polymerization shrinkage being the most clinically important one. Microleakage, may occur due to the failure of mechanically removing the infected tooth structure and incomplete sterilization of the preparation. Microleakage is a dynamic phenomenon defined as clinically undetectable penetration of fluid, bacteria, molecules and ions between the cavity walls and mounted restorative material. Even after advancements in both the material science and clinical techniques the problem of microleakage still exists; hitherto secondary caries and marginal discoloration is a routine finding. [1]

As conventional composite resins can only be cured to depth of 2mm, and hence consecutive layers are necessary to fill the cavity which is time consuming, technique sensitive and there is an intra-layer adhesion problem due to oxygen inhibition In order to counteract the inherent drawbacks of composite materials, newer clinical strategies have been introduced, like bulk-fill approach. Consequently, introduction of bulk- fill resins endeavour to expedite direct composite restorations in posterior teeth. Cavity can be filled in a single increment thereby simplifying the existing incremental technique. This also ensures reduced porosity and uniform consistency restoration, with reduced clinical time and cost for patient. [2]

Due to the paucity of microleakage studies on above mentioned materials the present study was designed to evaluate and compare the microleakage of Smart Dentin Replacement, Fiber Reinforced Composites (everX Posterior) and SonicFill with the use of standard methods i.e SEM and Stereomicroscopy.

MATERIALS AND METHODS

Sixty freshly extracted intact human mandibular premolars were extracted due to orthodontic reasons. They were collected, stored, disinfected and handled as per the recommendations and guidelines laid down by OSHA and CDC.

Class V cavity preparation with incisal margins in enamel and gingival margins in cementum were performed on the labial surface of each tooth. Preparations were centered on the CEJ and had the following dimensions: 3mm wide mesiodistally,3mm occlusogingivally, and2 mm deep axially. The samples were randomly and equally divided into 3 groups of 20 samples each.One coat of VII generation bonding agent G-Bond (GC Japan),xenoV (Dentsply, Switzerland) and Optibond(Kerr Corporation, USA) was applied to all the samples in group I,II and III respectively.When the surface had a uniform glossy appearance it was light cured for 10 seconds with a LED curing unit (Diagun, D-lux, Korea) of wavelength 450-470nm, held 1mm away from the cavosurface margin at constant intensity of 700Mw/cm^2.

All samples were restored with composite resins as follows:

Group I – Restored with everXPosterior(GC, Tokyo, Japan).Material was dispensed with the help of compule tip gun(Dentsply, Switzerland)
Group II – Restored with SDR(Dentsply, Switzerland) Material was dispensed with the help of compule tip gun(Dentsply, Switzerland)
Group III – Restored with sonicfill(Kerr Corporation, USA)using a sonicfillhandpiece(Kerr Corporation, USA).

Then all the groups were light cured for 20 seconds by using LED curing unit (Diagun, D-lux, Korea).

Each restoration was finished with So-Flex finishing discs operated at high speed using a water coolant.

Dye leakage

After the placement of the restorations, the teeth were stored in water at 37^{0}C, except when they were removed from storage and subjected to restorations. Restored teeth were stored in distilled water at room temperature for 24 hours before being subjected to 500 thermal cycles at 5^0-55^0 Celsius in a water bath with a dwell time of 15 seconds between the baths.

The samples were painted with nail polish(Elle 18) leaving 1 mm around the restoration. The nail varnish was allowed to dry for 24 hours. The specimens were then immersed in 0.5% Methylene blue dye in a glass jar solution in a cool place for 24 hours. They were then rinsed in running water for 10 minutes to remove excess dye. The samples were sectioned longitudinally into two equal halves through the center of the restoration in buccolingual direction using a carborundum disks at a slow speed in a micromotor handpiece**.**

Ten sections from each group were assessed for microgaps using SEM (Quanta 250) and ten sections from each group for the dye penetration readings at the restoration- tooth interface using a Stereomicroscope (Wild Heerbrugg stereomicroscope-15x) .the results were tabulated for the coronal, middle, and gingival third segments on a non- parametric scale.

Scoring Criteria

Data were summarized as Mean ± SD (standard deviation). Groups were compared by one way and two way analysis of variance (ANOVA) and the significance of mean difference within (intra) and between (inter) the groups was done by Tukey's post hoc test after ascertaining normality by Shapiro-Wilk's test and homogeneity of variance between groups by Levene's test. A two-tailed p value less than 0.05 (p<0.05) was considered statistically significant. Analyses were performed on SPSS software (windows version 17.0).

RESULTS

For each sample and group, the depth of penetration was assessed on gingival, middle and cervical sites. The comparative microgaps and depth of penetration of three groups is summarized below in section A and B respectively.

Comparison of microgaps of three groups using ANOVA

Source of variation (SV)	Sum of square (SS)	Degree of freedom (DF)	Mean square (MS)	F value	p value
Groups	1.53	2	0.77	2.13	0.139
Error	9.73	27	0.36		
Total	11.27	29	1.13		

Table: Comparison of depth of penetration between groups and sites using ANOVA

Source of variation (SV)	Sum of square (SS)	Degree of freedom (DF)	Mean square (MS)	F value	p value
Group	146289.36	2	73144.68	230.41	<0.001
Site	6377.16	2	3188.58	10.04	<0.001
Group x Site	49722.84	4	12430.71	39.16	<0.001
Error	25714.30	81	317.46		
Total	228103.66	89	89081.43		

The mean depth of penetration was highest in everX Posterior followed by SDR and SonicFill the least (everX Posterior > SDR >SonicFill). The mean microgaps was highest in everX posterior followed by SDR and SonicFill the least (everX Posterior >SDR >SonicFill).

Comparing the mean microgaps between two groups, Tukey test also showed similar (p>0.05) mircogaps between the groups though it lower 17.8% and 3.4% in SonicFill as compared to everX posterior and SDR respectively. comparing the mean depth of penetration between two groups, Tukey test showed significantly ($p<0.001$) different and lower depth of penetration in both SDR (61.0%) and SonicFill (65.4%) as compared to everX Posterior However, it did not differed ($p>0.05$) between SDR and SonicFill though it lower 11.4% more in SonicFill as compared to SDR .

DISCUSSION

Polymerisation shrinkage is directly related to the formation of internal stresses in the material and leakage between the restoration and the walls of the cavity and the postoperative sensitivity. [3, 4] In order to reduce the risk of microleakage ,bulk fill technique with newer composite materials have been used which are claimed to exhibit lower polymerization shrinkage and relatively lower microleakage as compared to conventional composite resins.

During initial polymerization in incremental technique, the superficial material layers achieves post gel phase faster than the deeper layers. So the superficial part becomes firm while the deeper part is still in the liquid form. With the application of material in increments , shrinkage stress is triggered.

Previous studies reported more microleakage in the gingival margins as compared to coronal margins especially when gingival margins were placed apical to the cementoenamel junction (CEJ), as in class V and deep class II cavities5. Dentin is a less favorable substrate than enamel for resin bonding. It was difficult to obtain good adhesion to dentine or cementum. In the present study, no material could completely eliminate microleakage at the cementum margin.

Self- etch bonding system was used for all three groups according to their manufacturer to keep the study uniform and standardized [6-8]. G-Bond, XenoV+ and Optibond all in one were used in the study for everX Posterior, SDR and SonicFill respectively. All these bonding agents are one-step self-etch bonding systems that forms a non-conventional interface with the dentin called a “Nano Interaction Zone” with minimal decalcification and almost no exposure to collagen fibres. This “nano” level reaction produces an insoluble calcium compound for a better bond that is less likely to deteriorate from enzymes present in the mouth. [9, 10]

In group I, everX Posterior is a bulk fill composite resin with E-glass fiber fillers whereas the conventional composite resin has particulate fillers. It usually indicates a thermosetting polyester matrix containing the glass fibers. In Fiber Reinforced Composites with an Interpenetrating Polymer Network (IPN) structure, the matrix consists of a cross-linking polymer, a linear polymer and a photo-initiator. Setting reactions in the resin matrix are polymerization reactions and cross-linking reactions. The reinforcing fiber prevents crack propagation by chemically bonding to the polymer matrix with covalent bonds. So FRCs havebetter mechanical and physical properties as compared to conventional resins. The short fiber composite resin has revealed control of the polymerization shrinkage stress by fiber orientation and thus reducing marginal microleakage compared with conventional particulate filler restorative composite resins. [11]

Group II consists of SDR which is marketed as a low-stress flowable base material that can be placed in layers upto 4 mm in thickness without negatively affecting polymerization shrinkage, cavity adaptation or degree of conversion. According to the manufacturer, it has extended polymerization without a sudden increase in cross-link density due to the polymerizable modulator (pre-polymerised urethane dimethacrylate resins) which is chemically embedded into the flowable resin material. This extended “curing- phase” maximizes the overall degree of conversion, minimizing the polymerization stress by upto 60% compared to conventional composite resins. Group III consists of SonicFill composite resins in which a handpiece is used for dispensing a resin–based composite filling material. The handpiece delivers sonic energy at varying intensities, which is adjusted on the shank from low to high (1 to 5) to control rate of composite extrusion. The specially designed resin contains modifiers that react to sonic vibrations to alter the viscosity of the material. The sonic energy reduces the viscosity of resin by 87% allowing adaptation in deep cavities, upto 5 mm, in a single increment. After the foot control is released, the sonic energy ceases and the resin returns to its high viscosity state, facilitating sculpting and carving to the desired anatomical form. It has greater radio-opacity than enamel, allowing easy detection of secondary caries. [12]

The result of the present study demonstrates thatno material could completely eliminate microleakage. Group III showed better results in comparison to Groups II and I.The reasons for better result in group III as comared to group I and II is due to the sonic activation in SonicFill, where it incorporates a highly filled proprietary resin with special modifiers that react to sonic energy [13]. As sonic energy is applied through the hand piece, the modifier causes the viscosity to drop (upto 87%), increasing the flowability of the composite enabling quick placement and precise adaptation to the cavity walls. When the sonic energy is stopped, the composite returns to a more viscous, non-slumping state that is perfect for carving and contouring.

When comparing the microleakage in this study, in group I i.e. everX Posterior, it was highest in gingival region of the restoration followed by coronal and least in middle. In both group II (SDR) and group III (SonicFill), it was highest in middle followed by coronal and gingival the least as both of them have less viscosity as compared to group I.

Results of microleakage may vary from specimen to specimen. However in the present study, main reasons for microleakage were viscosity of the material, different marginal adaptation and special modifiers in the composition of composite resins. Further clinical research is required to appraise the material's relevance to treatment outcome.

CONCLUSION

(Group III) showed the least micro-leakage and have better marginal adaptation as compared to (Group II) and (Group I).Statistically no significant differences was found in the microleakage of (group II) and (group III) whereas there was statistically significant difference between the microleakage of (group I) and other two in both SEM and Stereomicroscopic studies.

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