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Evaluation of Microleakage of Various Restorative Materials: An *in Vitro* Study

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ABSTRACT Microleakage is the clinically detectable passage of bacteria, fluids, molecules or ions between a cavity wall and the restorative materials applied to it. The aim of this study was to evaluate and compare the microleakage of six restorative materials viz., GC Fuji II LC, Ketac Molar Easy Mix, Filtek Z350, Filtek P60, Durafill VS and Dyract Restorative. Sixty caries-free premolars were divided into six groups (n = 10) and standard Class I cavities were restored with six different materials. Observation for marginal leakage was done under Stereomicroscope at 10X and data collected was subjected to statistical analysis. Concluding from the study, the sealing ability in terms of microleakage can be summarized as: Self-cured GIC (Ketac Molar Easy Mix) < Compomer (Dyract) < Packable composite (Filtek P60) < Resin modified Glass ionomer cement (GC Fuji II LC) d" Microfilled composite (Durafill VS) < Nanocomposite (Filtek Z350).

INTRODUCTION

There have been more changes and developments in dentistry over the past decade than in the previous hundred years combined, and the pace is accelerating! In the current age of adhesive dentistry or microdentistry, conservation of tooth structure is paramount. Rather than using extension for prevention as a treatment guideline, emphasis now is placed on restriction with conviction.

Microleakage is defined as the clinically detectable passage of bacteria, fluids, molecules or ions between a cavity wall and the restorative materials applied to it and is the major problem in clinical dentistry. Achieving a micromechanical and biomechanical bond between the restoration and tooth is considered effective and a standard procedure in clinical practice.

Instead of simply lathe-cut low copper amalgam or silicate cement, the menu of available materials has expanded to include hybrid, microfilled or optimal size particle, flowable or packable composites, glass ionomers, resin reinforced glass ionomers and compomers in varying viscosities (Korkmaz et al. 2010).

The ultimate success of a material is indicated by its longevity in the oral cavity. As the initial *in vitro* screening of new materials does not always reveal their full limitations or possibilities, clinical testing of new systems remains the ultimate proof of effectiveness. In the oral cavity, multiple and mutually interactive clinical variables related to tooth substrate and to its immediate environment, co-determine the eventual clinical effectiveness of newly developed adhesive materials as suggested by Hegde et al. (2009).

The objective of the present *in vitro* study, is to compare the sealing ability of the most innovative restorative materials being used in clinical practice, including Conventional Glass Ionomer Cements, Resin Modified GIC, Microfilled Composites, Packable Composites, Nanofilled Composites and Polyacid modified resin composites (Compomer).

MATERIALS AND METHOD

This study was conducted in the Department of Pedodontics and Preventive Dentistry, Guru Nanak Dev Dental College and Research Institute, Sunam. Sixty caries-free maxillary and mandibular premolars, extracted for orthodontic purposes were collected and used. The teeth were examined by trans-illumination to exclude teeth exhibiting enamel fractures as these might allow dye penetration. Calculus was removed with a scaler followed by cleaning with pumice slurry (in water) and rubber prophylaxis cup. The teeth were stored in distilled water with few thymol crystals added to it.

Class I cavities standardized to a size of

3x2x2mm dimensions were prepared in each sample with ISO Size (No.014) inverted cone and (No.010) straight fissured diamond burs using high speed water cooled hand piece.

Sixty samples were randomly divided into six equal groups, Group I to Group VI, consisting of 10 samples of each group and were filled according to manufacturer's instructions.

The samples were stored in distilled water at room temperature for 24 hours and final finishing and polishing of the restorations was done using fine finishing stones and polishing discs (Sof-lex, 3M ESPE). The specimens were then subjected to 1500 cycles of thermo-cycling between temperatures 12°C ± 2 to 60°C ± 2 with dwell time of 30 seconds and 10 seconds interval between the baths.

Teeth were covered with yellow sticky wax to occlude all the openings. Two coats of nail varnish were applied to all tooth surfaces except for 1mm around the restoration margins. The teeth were subjected to the dye solution of 50 percent Silver nitrate in small dark bottles for 4 hours and kept away from light. Then, the specimens were immersed in the photographic film developing solution- for 4 hours under 200 watt bulb, keeping the light source as close as possible.

After the dye exposure, the teeth were thoroughly cleaned under running tap water for 5 minutes to remove the superficial dye and then nail varnish was removed with the scalpel. Longitudinal sections were prepared with a Mandrel and diamond disk, in bucco-lingual direction, dividing the restoration at its midpoint mesiodistally exposing the tooth interface from cavosurface margin to the pulpal wall.

The degree of dye penetration in the occlusal cavity walls was assessed separately under a Binocular Stereomicroscope at 10X magnification. The part of the sectioned tooth which showed more reading for microleakage was considered in the study. The extent of dye penetration was determined at buccal and lingual/palatal wall from the occlusal portion of the restoration to base of the cavity along the tooth restoration interface, by the following scoring criteria given by Parbhakar et al. (2003).

0 : No dye penetration.

1 : Dye penetration between the restoration and the tooth into enamel only.

2 : Dye penetration between the restoration and the tooth in the enamel and dentin.

3: Dye penetration between the restoration and the tooth into the pulp chamber.

The data collected was tabulated and subjected to statistical analysis to compare the microleakage, using ANOVA and Unpaired t-test.

RESULTS

The mean microleakage scores of various restorative materials are depicted in Table 1. The analysis of variance for microleakage for different restorative materials used in the study was found to be significant (Table 2). The comparison of means of microleakage scores was done at buccal and palatal/lingual walls for different restorative materials used in study and it was found that there was no statistically significant difference obtained (Table 3). A significant difference was found in the microleakage values of Group I (GIC Fuji II LC), group II (Ketac Molar EM) and group VI (Dyract); whereas no significant difference of group I was found with other groups. There was a significant difference ($p < 0.05$) in the microleakage of Group II with all the other groups and the microleakage of Filtek Z350 (group III) was statistically significant with all the groups except with Resin modified glass ionomer cement (group I), Filtek P60 (group IV) and Durafill (group V). Statistically significant difference was found for microleakage scores of Group IV with resin Group II and Group VI. There was no significant difference in the microleakage scores of Group V with other groups except with Group II and Group V, whereas it was significant for Group VI with all the groups. The comparison of various different groups in their significance is shown in Table 4.

Table 1: Mean values (± s.d) of microleakage for various groups of restorative materials used in the study

Group	*Mean (m)*	*Upper value*	*Lower value*	*S.D*
Group I	0.4	2	0	0.753937
Group II	2.75	3	2	0.444262
Group III	0.05	1	0	0.223607
Group IV	0.55	3	0	0.759155
Group V	0.35	3	0	0.74516
Group VI	1.45	3	0	0.759155

It was observed from the obtained results that, the advanced restorative material nanocomposite, Filtek Z350 – displayed minimum microleakage while the microleakage of Self-cured

Table 2: Analysis of variance for microleakage for different restorative materials used in the study

Source of variation	*Degree of freedom*	*Variance ratio (F)*	*'p' value*	*Inference*
Between group	5	47.15	p < 0.05	Significant
Within group	54			
Total	59			

Analysis of variance for microleakage values with different restorative materials used in the study exhibited a significant relation (p < 0.05).

Table 3: Comparisons of means of microleakage scores at buccal and palatal/lingual walls for different restorative materials used in study

Groups (Buccal : Palatal/ Lingual Wall)	*'t' value*	*'p' value*	*Significance*
I	1.25	p > 0.05	Not significant
II	0.5	p > 0.05	Not significant
III	1.0	p > 0.05	Not significant
IV	0.27	p > 0.05	Not significant
V	0.57	p > 0.05	Not significant
VI	2.33	p > 0.05	Not significant

Table 4: Comparisons of means of microleakage with different restorative materials used in study

Groups	*'t' value*	*'p' value*	*Significance*
I : II	15.95	p < 0.001	Significant
I : III	2.375	p > 0.05	Not significant
I : IV	1.018	p > 0.05	Not significant
I : V	0.3393	p > 0.05	Not significant
I : VI	7.126	p < 0.001	Significant
II : III	18.32	p < 0.001	Significant
II : IV	14.93	p < 0.001	Significant
II : V	16.29	p < 0.001	Significant
II : VI	8.822	p < 0.001	Significant
III : IV	3.393	p > 0.05	Not significant
III : V	2.036	p > 0.05	Not significant
III : VI	9.501	p < 0.001	Significant
IV : V	1.357	p > 0.05	Not significant
IV : VI	6.108	p < 0.001	Significant
V : VI	7.465	p < 0.001	Significant

glass ionomer - Ketac Molar Easy Mix was found to be maximum (Fig. 1). So, the sealing ability in terms of microleakage was minimum for Self-cured GIC (Ketac Molar Easy Mix). The Compomer (Dyract) was showing lesser sealing property (Fig. 2) than the Packable composite (Filtek P60). It was also observed that the microleakage along the cavity walls was found to be more for Resin modified Glass ionomer cement (GC Fuji II LC) than Microfilled composite; Durafill VS (Fig. 3) and the best sealing quality (Fig. 4) was shown by the Nanocomposite (Filtek Z350).

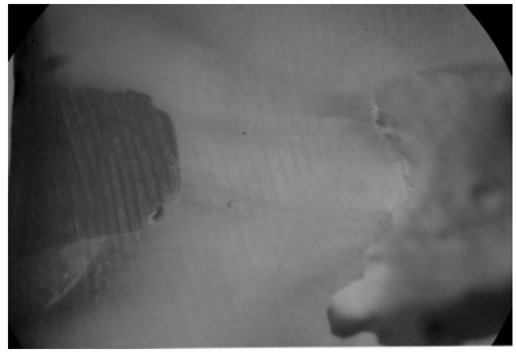

Fig. 1. Sample showing microleakage extending into the pulp chamber

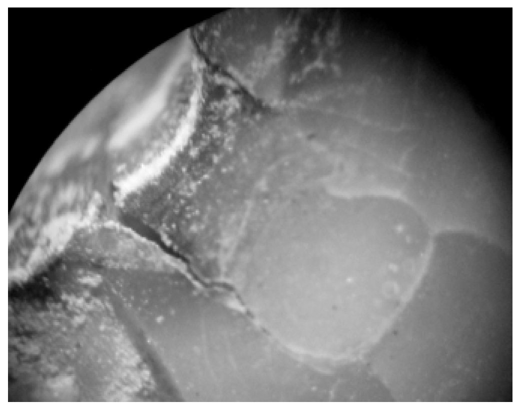

Fig. 2. Sample showing microleakage extending into enamel at the palatal wall with no microleakage at the buccal wall

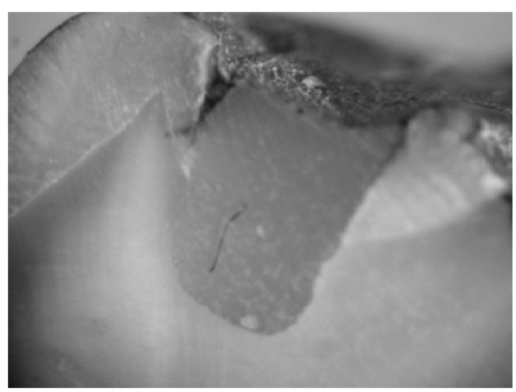

Fig. 3. Sample showing microleakage extending into enamel and dentin at both buccal and palatal walls

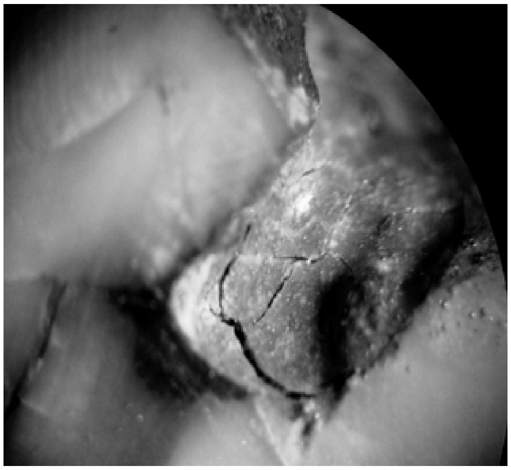

Fig. 4. Sample showing no microleakage

DISCUSSION

Restorative dentistry has seen a paradigm shift from the age old principle of "Extension for Prevention" as laid down by Sir G.V.Black to the recent principle of "restriction with conviction". After retrieving from distilled water with few thymol crystals, to maintain aseptic conditions before cavity preparation as cited by Mali et al. (2006), Class I cavities were prepared in each tooth. Class I cavities were selected because of its configuration or 'C' factor, which corresponds to the ratio between the number of bonded and unbounded surfaces as suggested by Roberson et al. (2002), Santini et al. (2004). This study used thermo-cycling to mimic intra-oral temperature variations and subjecting the restorations on the tooth to temperature extremes compatible with oral cavity.

The silver ion is extremely small 0.059 nm when compared to a typical bacterium which is 0.5-1.0 µm or internal diameter of dentinal tubules (1-4 µm), therefore, silver staining technique has been effectively used to study the degree of microleakage with a more superior definition and accurate evaluation of microleakage, as done by Mathew et al. (2001).

The 5th generation bonding agent, Prime and Bond NT was used as adhesive in this study, since it has the feature of reduced number of system components (1-bottle bonds) and is an acetone-based adhesive system which is more technique sensitive, suggested by Sano et al. (1998) and Arisu et al. (2009). Incorporated hydrophilic components are able to dislodge moisture from the conditioned dentin and attain an intimate interaction at the demineralized intertubular and peritubular dentin, creating the hybrid layer, which is essential for an ideal bond to dentin, as observed by Maleknejad et al. (2009). Santini et al. (2004), Kallenos et al. (2005) found that 5th generation bonding agents showed minimum microleakage as compared to 6th and 7th generation adhesive systems, so 5th generation adhesive was preferred to evaluate the microleakage of restorative materials in our study.

The sections were then examined using 0-3 calibration, which is a parametric scale giving a qualitative measurement of sealing effectiveness. The mean microleakage for Filtek Z350 was least that proves nanocomposites both stronger and more effective at preventing secondary decay. It provides a steady release of calcium and phosphate ions that are essential to the long-term success, as studied by Korkmaz et al. (2010).

Durafill VS, microfilled composite showed moderate microleakage because of the particle size which improves the flow of material due to improved viscosity and hence better adaptability. Also, water sorption of these materials compensates for polymerization shrinkage, which is attributed to less filler content, according to study conducted by Mccoy et al. (1998) and Hegde et al. (2009).

GC Fuji II LC, resin-modified glass ionomer cements showed higher adhesiveness to dentin than conventional glass ionomer cements, studied by Nakanuma et al. (1998) exhibiting moderate amount of marginal leakage.

Filtek P60, packable composite contain higher filler load as well as filler distribution, study conducted by Loguercio et al. (2004). They exhibited more microleakage than resin modified glass ionomers, microfilled and nanocomposites, but less than self-cured glass ionomers and compomers.

Dyract, compomer have minimal glass ionomer reactions, it is closer to a resin composite, thus exhibiting contraction stresses during polymerization that resulted in marginal gaps, exhibiting more marginal leakage.

Microscopically, the texture of Ketac Molar EM appeared as granulated with many cracks and air voids. The cohesive strength is found to be lower than adhesive strength. Thus, the porous nature of the material is an important factor that enhances potential of microleakage, in accordance with the study conducted by Cho et al. (1995) and Yaman et al. (2010).

CONCLUSION

All the restorative materials used in the study were unable to prevent the microleakage completely. Out of all the restorative materials, Filtek Z350 – the nanocomposite displayed minimum microleakage while the microleakage of Self-cured glass ionomer - Ketac Molar Easy Mix was found to be maximum. Concluding from the study, the sealing ability in terms of microleakage can be summarized as:

Self-cured GIC (Ketac Molar Easy Mix) < Compomer (Dyract) < Packable composite (Filtek P60) < Resin modified Glass ionomer cement (GC Fuji II LC) < Microfilled composite (Durafill VS) < Nanocomposite (Filtek Z350).

REFERENCES

Arisu HD, Eliguzeloglu E, Uctasli MB, Omurlu H, Turkoz E 2009. Effect of multiple consecutive adhesive coatings on microleakage of class v cavities. *Eur J Dent*, 3:178-84.

Cho E, Kopel H, White SN 1995. Moisture susceptibility of resin-modified glass-ionomer materials. *J of Quintessence International,* 5: 26-29.

Hegde MN, Vyapaka P, Shetty S 2009. A comparative evaluation of microleakage of three different newer direct composite resins using a self-etching primer in class V cavities: An *in vitro* study. *J Conserv Dent*, 4: 160–163.

Kallenos TN, Al-Badawi E, White GE 2005. An *in vitro* evaluation of microleakage in Class I preparation using 5th, 6th, 7th generation composite bonding agents. *J of Clinical Pediatric Dentistry,* 4: 29-32.

Korkmaz Y, Ozel E, Attar N, Bicer CO, Firatli E 2010. Microleakage and scanning electron microscopy evaluation of all-in-one self-etch adhesives and their respective nanocomposites prepared by erbium:yttrium-aluminum-garnet laser and bur. *Lasers Med Sci,* 4: 493-502.

Loguercio AD, de oliverre Bauer JR, Reis A, Grade RH 2004. *In vitro* microleakage of packable composites in Class II restorations. *Quintessence International,* 1: 35-38.

Mali P, Deshpande S, Singh A 2006. Microleakage of restorative materials, an *in vitro* study. *J of Indian Society of Pedodontics and Preventive Dentistry,* 1: 24-27.

Maleknejad F, Moosavi H, Shahriari R, Sarabi N, Shayankhah T 2009. The effect of different adhesive types and curing methods on microleakage and the marginal adaptation of composite veneers. *J Contemp Dent Pract,* 3: 18-26.

Mathew M, Nair EKP, Krishan K 2001. Bonding agent is a decisive factor in determining the marginal leakage of dental composites subjected to thermal cycling: An *in vitro* study. *J of Oral Rehabilitation,* 28: 68-77.

Mccoy RB, Anderson MH, Lepe X, Johnson GH 1998. Clinical success of Class V composite resin restorations without mechanical retention. *J of American Dental Association*, 6: 129-134.

Nakanuma K, Hayakawa T, Tomita T, Yamazaki M 1998. Effect of the application of dentin primers and a dentin bonding agent on the adhesion between the resin-modified glass-ionomer cement and dentin. *J of Dent Mater*, 14: 281–286.

Parbhakar AR, Madan M, Rju OS 2003. Marginal seal of flowable composites, injectable resin modified Glass Ionomer and composites in primary molars an *in vitro* study. *J of Indian Society of Pedodontics and Preventive Dentistry,* 2: 21-25.

Roberson TM, Heymann HO, Swift EJ 2002. *Sturdevant's Art and Science of Operative Dentistry*, 4: 237-268.

Santini A, Ivanovic V, Ibbetson R, Milia E 2004. Influence of cavity configuration on microleakage around Class V restorations bonded with seven self-etching adhesives. *J Esthet Restor Dent,* 2: 128-135.

Santini A, Ivanovic V, Ibbetson R, Milia E 2004. Influence of marginal bevels on microleakage around Class V cavities bonded with seven self-etching agents. *Am J Dent*, 4: 257-261.

Yaman BC, Efes BG, Dörter C, Gömeç Y, Erdilek D, Yazýcýoðlu O 2010. Microleakage of repaired class V silorane and nano-hybrid composite restorations after preparation with erbium: Yttrium-aluminum-garnet laser and diamond bur. *Lasers Med Sci*, 6: 312-316.