

Microleakage of Class II Cavity Preparation Restored with Three Different Dental Composite Restorative Materials (A Comparative *In Vitro* Study)

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Abstract

This in-vitro study aimed to evaluate marginal microleakage of CL II cavity preparation restored with three types of resin based dental composite. Forty-five sound maxillary first premolar teeth were selected and standardized Class II box only cavities were prepared in the mesial surface of each tooth. The teeth then were restored with micro-filled resin hybrid universal composite (G-aenial POSTERIOR, GC japan). Nano-hybrid universal composite (Filtek™ Z350 XT, 3 m ESPE Germany). Nanofiber reinforced nano-hybrid universal composite (NovaPro™ Fill, nanovausa). After finishing, the teeth were subjected to 500 thermal cycles at 5°-55°C and mechanical load cycling (50,000 load cycle of 50 N). Teeth were kept in 2% methylene blue for 3 days and then blocked in clear acrylic before sectioning with microtome. Microleakage was evaluated by stereomicroscope (20 X). Data were analyzed statistically by Kruskal-Wallis test. The least microleakage occurred around the group C (NovaPro™ Fill) and the maximum microleakage was seen in group B (Filtek™ Z350 XT) but there was no statistically significant difference between the groups.

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Introduction

Dentistry had always thrived to achieve biocompatible restorations that do not compromise the pulp and maintain the dental seal. One of the significant contributions has been the development of resin-based composite technology [1]. Developments in filler technology and initiator systems have considerably improved composite physical properties and expanded their clinical applications [2].

Despite these new advances, micro leakage remains a major problem especially at the gingival margin of class II restorations [3,4]. The microleakage, at the tooth-restoration interface is the main cause of failure of adhesive restorations, affecting retention and marginal adaptation [5].

There are many factors that affect microleakage at the tooth-restoration interface, including the bond strength between the adhesive and the tooth structure, residual stresses due to polymerization shrinkage of the composite resin, discrepancies between the thermal expansion coefficients of enamel and dentin on one hand and that of the restorative material on the other hand, and occlusal forces [6].

The major problem of resin-based composite remains polymerization shrinkage which results from resin contraction during curing inducing internal and interfacial stresses at the tooth restoration interface, leading to gap formation and subsequent marginal leakage

[7]. Polymerization shrinkage has been reported to be in the range of 3% [8].

To reduce the polymerization shrinkage, researchers have mainly focused in changing either the material's formulation or the mechanism of initiating polymerization [9]. Less polymerization shrinkage can be obtained if the total amount of composite material for restoration of a class II cavity is reduced [10]. Furthermore, different methods such as reducing the composite polymerization rate, using the incremental placement technique and reducing the C-factor have been suggested to decrease the microleakage of resin composite materials [3,10].

Reinforcing the resin with glass fibers with fiber-reinforced composite (FRC) substructure whiskers particulate ceramic fillers (dense and porous) and optimization of filler content are among the methods that have been studied [11].

Micro-leakage remains a matter of concern because it leads to entry of the microorganisms, saliva and other fluids in the mouth to the space between the teeth and filling material, so it causes sensitivity after dental work, marginal discoloration, recurrent caries, pulp damage, and ultimately failure [12,13].

Materials and Method

Forty-five intact maxillary first premolar extracted for orthodontic reasons were used in this *in-vitro* study. After extraction, teeth were



stored in distilled water with 0.1% thymol solution at room temperature [14]. Teeth were cleaned from any adhering soft tissues and calculus deposits [15]. Any tooth with craze lines, decay, abrasion, previous restorations, structural deformities, or cervical lesions were excluded [16].

The outline of the cavity preparation was painted with a waterproof color marker. The cavity dimensions were 3 mm in the buccolingual dimension at occlusal; 3 mm in the buccolingual dimension at the gingival floor and 2 mm mesiodistally [17]. The depth of the cavity was 4 mm. The teeth were mounted in manikin model using dental surveyor [18]. The whole cavity preparation procedure was performed using parallel sides, flat end diamond bur placed in high speed hand piece under profuse water cooling. The bur was replaced by a new one after four cavity preparations.

The cervical margin of the proximal cavity was located 1mm occlusal to the cemento-enamel junction. The internal angles were rounded. The cavity margins were prepared to be butt joint. The depth was standardized using a marker placed along the bur shank [19].

Teeth were randomly divided into 3 main groups (each contained 15 samples):

- **Group A:** Teeth were restored with micro fill hybrid universal composite (G-aenial POSTERIOR, GCJapan).
- **Group B:** Teeth were restored with nano-hybrid universal composite (Filtek™ Z350 XT, 3 m ESPE Germany).
- **Group C:** Teeth were restored with nanofiber reinforced nano-hybrid universal composite (NovaPro™ Fill, Nanova USA)

After preparation, the Cavities were dried using gentle air blast and conditioned with 37% phosphoric acid gel for 15 second followed by 30 second rinsing with water and excess water was removed by applying a gentle stream of air for 2 seconds [20].

The adhesive (Scotchbond™ Universal Adhesive) was applied using microbrush and rubbing the cavity walls for 20 seconds followed by air drying for 5 seconds to evaporate the solvent and finally light curing for ten seconds according to the manufacturer's instructions.

With each group palodont sectional matrix system was fitted onto the prepared tooth before the application of the restorative material. Then, the cavities were restored with G-aenial POSTERIOR, Filtek™ Z350 XT, NovaPro™ Fill using incremental technique (2 mm) then light cured for 20 sec. LED curing light in soft start polymerization mode (light intensity up to 2100 mW/cm²).

For all groups DeOX® oxygen barrier solution was used to prevent the oxygen inhibiting layer formation [21].

After that the matrix was removed and the restorations were light cured for 20 sec from the buccal and lingual surfaces and the margins of the restoration were finished and polished using Opti discs finishing and polishing system (Kerr, Switzerland). All the restored teeth were then stored in distilled water at 37°C in a dark container for 48 hours [22].

To simulate the clinical situation. All specimens were subjected to thermal changes cycles by cycling the teeth between two custom made water baths maintained at 5±1°C and 55±1°C, with a dwell time of 20 sec. The number of cycles was 500 cycles according to the International Organization for Standardization (ISO TR 11405) [23,24].

The teeth were mounted with the aid of dental surveyor into a

filled with cold cure acrylic in a dough stage periodontal ligament was simulated with addition silicone impression material by injection into the mold and reinserting the teeth [25,26].

All the specimens were subjected to mechanical load cycling (50,000 cycles, 5.5 hours) to obtain an axial force of approximately 50 N [27].

The roots tips were protected with wax. The teeth surfaces (leaving 1mm margin around the filling in cervical margin) were coated with 2 coats of nail varnish. The prepared samples were placed in a 2% methylene blue solution for 3 days at 37°C using an incubator.

The specimens are blocked with clear cold cure acrylic and were sectioned longitudinally through the center of the restorations in a mesiodistal direction with a Low Speed Diamond Saw (0.35 mm).

For the dye penetration evaluation one of the two hemi sections of each tooth showing the clearest dye penetration was selected for examination under a stereomicroscope at 20× magnification to assess the extent of microleakage. The dye penetration was analyzed qualitatively according to 0-4 scale:

- No dye penetration.
- 1-Dye penetration extending to 1/3 third of the gingival wall.
- Dye penetration extending to 2/3 third of the gingival wall.
- Dye penetration into whole of the gingival wall.
- Dye penetration into the gingival wall and axial walls toward the pulp.

Statistical analysis

In this study, statistical analysis was performed by using IBM SPSS Statistics. The microleakage data are qualitative (continuous) data. The data was analyzed using Kruskal-Wallis test (p≤0.05) at 95% confidence level to detect the significant differences among the groups.

Results

Data that represented the microleakage at teeth/composite gingival interfaces of Class II restoration were examined by Stereomicroscope and then recorded as scores (0, 1, 2, 3, and 4) (Table 1).

The Descriptive statistics for each group are summarized in the below table (Table 2).

The statistical analysis of data was done by Kruskal-Wallis non-parametric test to analyze the presence of statistically significant difference for the microleakage scores between the groups (Table 3).

Assessing the significance of H value depends on the number of samples and the number of groups. In this *in-vitro* study, we have three groups (each group has 15 samples). Since we have more than five observation per group, then we treat H value as Chi-Square (Table 4).

As a result of H value (0.57) smaller than the critical value of Chi-Square (0.909) for degree of freedom 2, then we retain the null hypothesis that the distribution of leakage is the same across categories of groups.

Table 1: Frequency distributions of microleakage scores.

Group	Sample size	Score 0	Score 1	Score 2	Score 3	Score 4
A	15	0	0	2	3	10
B	15	0	0	1	2	12
C	15	0	1	1	3	10



Table 2: Descriptive statistics of micro leakage score.

Group	Minimum	Maximum	Mean	Median	Variance	Std. Deviation
A	2	4	3.53	4.0000	0.552	0.74322
B	2	4	3.73	4.0000	0.352	0.59362
C	1	4	3.47	4.0000	0,838	0.915

Table 3: Statistical analysis of data by Kruskal-Wallis test.

Test	Statistical value	P-value
Kruskal-Wallis H Test	0.57	0.05

Table 4: Test Statistics.

Test	Scores
Chi-Square	0.909
D.F	2
Asymp. Sig.	0.635

Discussion

Microleakage tests are used to study the mechanisms that may minimize, or eliminate, the leakage around dental restorations. Although the clinical relevance of the leakage tests does not always correlate precisely with the clinical situation, a microleakage test is a useful method in the investigation of resin composite restorations [23].

Previous research has shown that microleakage occurred more at the gingival margin than at the occlusal margins [10]. For this reason, this study aimed to evaluate the microleakage at the gingival margins.

The statistical analysis showed that group C (NovaPro™ Fill, Nanova, USA) had the lowest mean rank. This means that it showed the least amount of microleakage among the three groups and is the best material in this study from the microleakage point of view, followed by group A (G-aenial Posterior, GC, Japan) and finally the highest microleakage amount was in group B (Filtek™ Z350 XT, 3M ESPE, Germany). But there was no statistically significant difference between the groups.

The best possible explanation for these results is that NovaPro™ Fill a nano-hybrid universal composite has been reinforced with short hydroxyapatite nanofibers (100-150 micrometer in length, 50-200 nanometer in width).

Short fiber reinforced composite resin was introduced as a dental restorative composite resin to be used in high stress bearing areas especially in molars. The short fiber composite resin has also revealed control of the polymerization shrinkage stress by fiber orientation and, thus, marginal micro leakage was reduced compared with conventional particulate filler composite resins [28]. Polymerization shrinkage varies in anisotropic materials where fibers are oriented in different planes and the shrinkage is not equal to all directions. Polymerization shrinkage is controlled in direction of fibers significantly. Thus, during polymerization of fiber reinforced composites the material will not be able to shrink along the length of the fibers which support the reduced microleakage scores in the fiber reinforced composites [29].

This supported by various studies. Patnana AK, et al. (2017) in a study evaluating the marginal Integrity of Bulk Fill Fiber Reinforced Composites found that short glass fiber reinforced composites (ever X Posterior; GC, Tokyo, Japan) which was introduced to the dental market in 2013 was showing the least microleakage compared to other experimental groups [30].

Tezvergil A, et al. (2005) in a study done in 2006 compared the

polymerization shrinkage strain of glass fiber reinforced composites and particulate filler composites and concluded that fiber reinforced composites showed a reduced microleakage scores when compared to the particulate filler composites [31]. A laboratory study reported by El-Mowafy O, et al. (2007), showed that experimental group with glass and polyethylene fibers at the gingival margins showed reduced microleakage than control group (particulate filler composites) [10]. It can be explained as the fibers replace part of the composite increment at this location, resulting in a decrease in the overall volumetric polymerization contraction of the composite [30].

Another study by Ferracane JL (2011) found that a combination of flowable composites beneath the short fiber reinforced composites showed meaner microleakage scores than the restorations with fiber reinforced composites alone. However, the results were not statistically significant [32].

On the other hand, a study by Tekriwal S, et al. (2017) comparing microleakage in Class V cavities between ever X. Posterior with smart dentin replacement and Sonic Fill found that ever X Posterior had worst marginal adaptation as compared to smart dentin replacement and SonicFill [33]. Class II cavities restored with fiber reinforced composites also showed that gingival margins had higher marginal microleakage than the occlusal margins [28,30]. The use of glass and polyethylene fiber inserts had no significant effect on the microleakage in class II resin composite restorations with gingival margins on the root surface [13].

In the end, all groups showed dye penetration at the tooth-restoration interface. This could be attributed to the dimensional changes of the resin material which often result from polymerization shrinkage of the restorative resin, and differences in coefficient of thermal expansion and contraction between the tooth and the restorative material. These changes in the material produce internal forces that results in gap formation at the tooth-restoration interface, which in turn causes micro leakage [33,34].

References

- Mitra SB, Wu D, Holmes BN (2003) An application of nanotechnology in advanced dental materials. *J Am Dent Assoc* 134: 1382-1390. <https://doi.org/10.14219/jada.archive.2003.0054>
- Sooraparaju SG, Kanumuru PK, Nujella SK, Konda KR, Reddy K, et al. (2014) A comparative evaluation of microleakage in class v composite restorations. *Int J Dent* 2014: 685643. <https://doi.org/10.1155/2014/685643>
- Ozel E, Soyman M (2009) Effect of fiber nets, application techniques and flowable composites on microleakage and the effect of fiber nets on polymerization shrinkage in class II MOD cavities. *Oper Dent* 34: 174-180. <https://doi.org/10.2341/08-57>
- Agrawal VS, Parekh VV, Shah NC (2012) Comparative evaluation of microleakage of silorane-based composite and nanohybrid composite with or without polyethylene fiber inserts in class II restorations: an in vitro study. *Oper Dent* 37: 1-7. <https://doi.org/10.2341/11-353-L>
- De Munck J, Van Landuyt K, Coutinho E, Poitevin A, Peumans M, et al. (2005) Micro-tensile bond strength of adhesives bonded to Class-I cavity-bottom dentin after thermo-cycling. *Dent Mater* 21: 999-1007. <https://doi.org/10.1016/j.dental.2004.11.005>
- Duarte Jr S, Dinelli W, Silva MH (2007) Influence of resin composite insertion technique in preparations with a high C-factor. *Quintessence Int* 38: 829-835.
- Attar N, Turgut MD, Gungor HC (2004) The effect of flowable resin composites as



- gingival increments on the microleakage of posterior resin composites. *Oper Dent* 29: 162-167.
8. Anusavice KJ (2003) Phillips' science of dental material. (11thedtn), Elsevier Inc., United States.
 9. Schneider LF, Cavalcante LM, Silikas N (2010) Shrinkage stresses generated during resin-composite applications: a review. *J Dent Biomech* 2010: 131630.<https://dx.doi.org/10.4061/2010/131630>
 10. El-Mowafy O, El-Badrawy W, Eltanty A, Abbasi K, Habib N (2007) Gingival microleakage of Class II resin composite restorations with fiber inserts. *Oper Dent* 32: 298-305.<https://doi.org/10.2341/06-86>
 11. Kumar JS, Jayalakshmi S (2016) Failure and its prevention in composite restoration-a review. *J Pharm Sci Res* 8: 627-631.
 12. Belli S, Orucoglu H, Yildirim C, Eskitascioglu G (2007) The effect of fiber placement or flowable resin lining on microleakage in Class II adhesive restorations. *J Adhes Dent* 9: 5-181.
 13. Sharafeddin F, Zare S, Javnmardi Z (2013) Effect of home bleaching on microleakage of fiber-reinforced and particle-filled composite resins. *J Dent Res Dent Clin Dent Prospects* 7: 211-217.<https://dx.doi.org/10.5681/joddd.2013.034>
 14. Özcan M, Barbosa SH, Melo RM, Galhano GA, Bottino MA (2007) Effect of surface conditioning methods on the microtensile bond strength of resin composite to composite after aging conditions. *Dent Mater* 23: 1276-1282.<https://doi.org/10.1016/j.dental.2006.11.007>
 15. Turkaslan S, Tezvergil-Mutluay A, Bagis B, Vallittu PK, Lassila LV (2009) Effect of fiber-reinforced composites on the failure load and failure mode of composite veneers. *Dent Mater J* 28: 530-536.<https://doi.org/10.4012/dmj.28.530>
 16. Jia S, Chen D, Wang D, Bao X, Tian X (2017) Comparing marginal microleakage of three different dental materials in veneer restoration using a stereomicroscope: An in vitro study. *BDJ Open* 10: 1-5.<https://doi.org/10.1038/bdjopen.2016.10>
 17. Gharizadeh N, Moradi K, Haghhighizadeh MH (2007) A study of microleakage in Class II composite restorations using four different curing techniques. *Oper Dent* 32: 336-340.<https://doi.org/10.2341/06-98>
 18. El-Nawawy M, Koraitim L, Abouelatta O, Hegazi H (2012) Marginal adaptation of nanofilled, packable and hybrid dental composite resins stored in artificial saliva. *J Am Biomed Eng* 2: 105-114.<https://doi.org/10.5923/j.ajbe.20120203.03>
 19. Dalia MT, Mahmoud M, El-Sayed M (2016) Microleakage of class II composite restorations with different restorative techniques (an in vitro study). *Alex Dent J* 41: 138-145.<https://dx.doi.org/10.21608/adjalexu.2016.59268>
 20. Abdulameer S, Shukri BMS (2017) Microleakage of class II cavity preparation restored with two different Bulk Fill Composite using different adhesive techniques (In vitro comparative study). A thesis to College of Dentistry, Al-Mustansiriyah University, Iraq.
 21. Magne P (2005) Immediate dentin sealing: a fundamental procedure for indirect bonded restorations. *J Esth Restor Dent* 17: 144-155.<https://doi.org/10.1111/j.1708-8240.2005.tb00103.x>
 22. Poggio C, Chiesa M, Scribante A, Mekler J, Colombo M (2013) Microleakage in Class II composite restorations with margins below the CEJ: In vitro evaluation of different restorative techniques. *Med Oral Patol Oral Cir Bucal* 18: 793-798.<https://dx.doi.org/10.4317/medoral.18344>
 23. Pazinato FB, Campos BB, Costa LC, Atta MT (2003) Effect of the number of thermocycles on microleakage of resin composite restorations. *Pesqui Odontol Bras* 17: 337-341.<https://doi.org/10.1590/S1517-74912003000400008>
 24. Reis A, Loguercio AD, Kraul A, Matson E. Reattachment of fractured teeth: a review of literature regarding techniques and materials. *Oper Dent* 29: 226-233.
 25. Jalali H, Sadighpour L, Miri A, Shamshiri AR (2015) Comparison of marginal fit and fracture strength of a cad/cam zirconia crown with two preparation designs. *J Dent (Tehran)* 12: 874-881.
 26. Marchionatti AM, Wandscher VF, Broch J, Bergoli CD, Maier J, et al. (2014) Influence of periodontal ligament simulation on bond strength and fracture resistance of roots restored with fiber posts. *J Appl Oral Sci* 22: 450-458.<https://doi.org/10.1590/1678-775720140067>
 27. Ismael DB, Hameed MR (2016) Evaluation of marginal adaptation of a Class V composite resin restoration with different surface treatments after thermal and mechanical load cycling (An in vitro study). A thesis to College of Dentistry, Baghdad university, Iraq.
 28. Garoushi S, Vallittu PK, Watts DC, Lassila LV (2008) Polymerization shrinkage of experimental short glass fiber reinforced composite with semi-inter penetrating polymer network matrix. *Dent Mater* 24: 211-215.<https://doi.org/10.1016/j.dental.2007.04.001>
 29. Garoushi S, Mangoush E, Vallittu M, Lassila L (2013) Short fiber reinforced composite: A new alternative for direct onlay restorations. *Open Dent J* 7: 181-185.<https://dx.doi.org/10.2174/1874210601307010181>
 30. Patnana AK, Vanga VNR, Chandrabhatla SK (2017) Evaluating the marginal integrity of bulk fill fibre reinforced composites in bio-mimetically restored tooth. *J Clin Diagn Res* 11: 24-27.<https://dx.doi.org/10.7860/JCDR/2017/27835.10049>
 31. Tezvergil A, Lassila LV, Vallittu PK (2005) The effect of fiber orientation on the polymerization shrinkage strain of fiber-reinforced composites. *Dent Mater* 22: 610-616.<https://doi.org/10.1016/j.dental.2005.05.017>
 32. Ferracane JL (2011) Resin composite-state of the art. *Dent Mater* 27: 29-38.<https://doi.org/10.1016/j.dental.2010.10.020>
 33. Tekriwal S, Kumar A, Rajkumar B, Gupta V, Bhatt A (2017) Comparative evaluation of microleakage of three newer composite resins using SEM and Stereomicroscopy: An *in-vitro* study. *Res J Pharm Biol Chem Sci* 8: 1292-1297.
 34. Ellias E, Sajjan G (2002) Effects of bleaching on microleakage of resin composite restorations in non-vital teeth: An *in-vitro* study. *J Endod* 14: 9-13.