RESEARCH ARTICLE

EVALUATION OF MICROLEAKAGE AND INTERNAL VOIDS IN CLASS II COMPOSITE RESIN RESTORATION USING FLOWABLE AND PACKABLE COMPOSITE RESIN WITH VARIOUS CURING PROTOCOLS USING STEREOMICROSCOPE - AN IN VITRO STUDY

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ABSTRACT

AIM-Microleakage and internal voids were evaluated in classII composite resin restoration using flowable and packable composite resin with various curing protocols. METHODOLOGY-Thirty non carious molar teeth were taken, class II cavities were prepared, acid etching was done and randomly divided into three groups: Group I-Bonding agent was placed, cured and samples were restored with packable composite resin and then cured again; Group II- Bonding agent was placed and cured, samples were lined with flowable composite and cured. Subsequently cavities were restored with packable composite resin and cured again. Group III- Bonding agent was placed and samples were lined with flowable composite resin and cured together and restored with packable composite resin and cured. Longitudinal sections were made in mesio-distal direction and were examined under a stereomicroscope. Internal voids was recorded in the cervical and occlusal surfaces of restorations. Gingival-marginal microleakage was also be recorded. RESULTS- The mean microleakage and void score of group I is higher compared to other groups and the mean microleakage and void score of group II is lowest compared to other groups. CONCLUSION- According to this in vitro study it can be concluded that within the limitations of this study, it is preferable to cure the flowable composite liner separately followed by curing of packable composite to reduce microleakage and internal voids.

KEY WORDS

Microleakage, Internal Voids, Flowable And Packable Composite Resin, Class II Cavity

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INTRODUCTION

Composite resins have become one of the most commonly used direct restorative materials for anterior and posterior teeth.[1] But one of the inevitable drawbacks of dental composites is shrinkage during free radical polymerization, which may be as high as 3% by volume causing microleakage, secondary caries and postoperative sensitivity. The reduction of the gap formation was always a challenge to the researchers and as a result newer methods and materials were introduced.[2]

Before the introduction of acid etching, bonding system was able to resist only 2-3 MPa of stress while approximately 17 MPa are necessary to resist the contraction stresses at resin dentin interface to prevent debonding. With the introduction of acid etching (1979) upto 22 MPa stress could be resisted. Adhesion of dental resins to enamel and dentin has progressed dramatically in the 40 years since Buonocore introduced the technique of etching enamel with phosphoric acid to improve the adhesion of resin filling materials. Enamel is homogeneous in nature and is primarily composed of hydroxyapatite. Etchants dissolve hydroxyapatite crystals in enamel, creating pits by which the adhesive resin is readily absorbed by capillary attraction creating macrotags of resin that envelop the individually exposed hydroxyl appetite crystals. Additionally resin microtags extend within tiny etch pits in the enamel prism cores. Resin tags in the interprismatic spaces provide for the majority of micromechanical adhesion. In comparison, dentin is heterogeneous, consisting of hydroxyapatite and collagen. The degree of mineral content in dentin is quite variable, depending on whether it is near the DEJ or deeper in close proximity to the pulp. Overall, the water content of dentin is significantly higher than enamel, posing another challenge to adhesive bonding [3,4]

Packable composite was developed by changing the shape, size and particle distribution of filler or matrix phase to increase viscosity for better condensation similar to that of amalgam. [5,6]

Flowable composites were introduced in late 1996. They have a filler size similar to hybrid composites but a lower filler content (weight: 60%-70%; volume: 46%-65%) than their hybrid analogs (weight: 70%-80%; volume: 60%-75%) (Chuang & others, 2001a).[7] They are nonsticky and injectable. They have low viscosity and increased wettability due to lower filler content. Flowable composite as a lining material for class II resin composites reduced voids.[8] Considering the advantages and disadvantages of various types of composites and techniques, a technique was introduced by Jackson and Morgan 2000 where a thin layer of flowable composite is applied to cavity floor which is immediately followed by packable composite increment and light cured. [9]

When used in lining materials beneath resin composite restorations, flowable composites may improve marginal adaptation (Alomari, Reinhardt & Boyer, 2001; Payne, 1999; Belli & others, 2001). Compared with injectable glass ionomers, Payne (1999) reported a reduction in microleakage of flowable composite in ClassII restorations, especially at the cavosurface margin of the proximal box. Tung, Estafan and Scherer (2000) evaluated microleakage in Class II cavities restored with a composite placed with or without a liner and found that a flowable composite should be used as a liner.[10,11]

There are other potential clinical problems that can arise when using traditional hybrid resin-based composites in Class II cavity preparations. Voids at gingival marginal areas can result from the inability to adequately adapt the materials to margins before curing (Nash, Lowe & Leinfelder, 2001).[12,13,14]

MATERIAL & METHODS

Freshly extracted thirty human molars were collected and stored in 5.25% sodium hypochlorite at a temperature of 37°C for 15 days and were mounted on plaster of paris with one premolar and one molar on the mesial and distal sides to simulate posterior tooth alignment and class II cavities were prepared with standardized mesioocclusal and disto occlusal box only having bucco-lingual width 4 mm, mesio distal width 2 mm and occluso gingival depth of 3 mm. Ivory no.8 retainer with matrix band was placed which was stabilized with wooden wedges. They were etched with 37% phosphoric acid, (N-Etch, ivoclar vivadent) washed thoroughly with water by a three way syringe for 15 seconds and followed by the application of the two layers of ADPER single bond (3M ESPE) by applicator tip and each layer was cured with LED light for 10 seconds.

Material	**Product Name**	**Manufacturer**
Etchant	N-Etch	IvoclarVivadent
Bonding Agent	ADPER single bond	3M ESPE
Flowable Composite	FILTEK Z 350 XT	3M ESPE
Packable Composite	FILTEK P60	3M ESPE

Group I- Teeth were restored with FILTEK P60(3M ESPE) composite resin and then cured with LED light for 30seconds.

Group II- Teeth were lined with FILTEK Z350 XT(3M ESPE) composite resin and cured with LED light and restored with FILTEK P60 (3M ESPE) composite resin and cured with LED light,

Group III- Teeth were lined with FILTEK Z350 XT (3M ESPE) composite resin and restored with FILTEK P60(3M ESPE) composite resin and then cured with LED light together.

The samples were stored in normal saline at a temperature of 37°C for 24 hours and placed in a thermocycling machine for 1,500 cycles ranging from 5°C to 60°C. The samples were coated with nail varnish except for the restoration and one millimeter beyond the margins, then soaked in 2% methylene blue dye for 24 hours. Samples were sectioned with a diamond disc and water spray mesio-distally and were examined under a stereomicroscope with 20X magnification. Internal voids were recorded in the cervical and occlusal surfaces of restorations. Microleakage was recorded in gingival-margin under a stereomicroscope with 20X magnification.

	GROUP I	GROUP II	GROUP III
Tooth Preparation	✓	✓	✓
Etching	✓	✓	✓
Application of Bonding agent	✓	✓	✓
Curing of Bonding agent	✓	✓	✓
Application of flowable composite	_	✓	✓
Curing of flowable composite	_	✓	_
Incremental placement of restorative material	✓	✓	✓
Curing of restorative material	✓	✓	✓

✓indicates procedures done
_ indicates procedures not done.

The scoring scales for microleakage: According to Chuang SF et al.

0 = no leakage

1 = leakage extending to the half of the cervical wall: light

2 = leakage to the full extension of the cervical wall, but not including the axial wall: moderate

3 = leakage to the full extension of the cervical wall and including the axial wall: severe

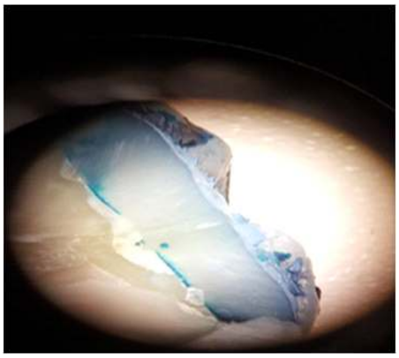
Scores for recording voids were: According to Chuang SF et al.

Score 0 = no void

Score 1 = some voids exist.

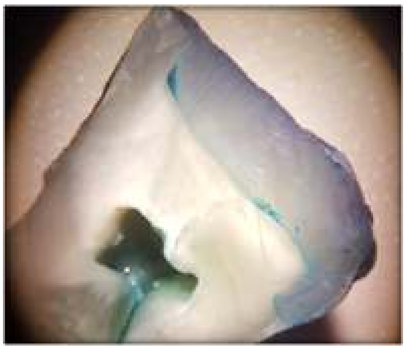
Class II cavity

STEREOMICROSCOPE



Stereomicroscope image of group I depicting microleakage and void

Stereomicroscope image of group II depicting microleakage and void



Stereomicroscope image of group III depicting microleakage and void

DATA ANALYSIS

Descriptive statistical analysis was performed to calculate the means with corresponding standard deviation (s.d). One way analysis of variance followed by post hoc Tukey test was performed with the help of critical difference (CD) or least significant difference at 5% and 1% level of significance to compare the mean values.

RESULT

According to Statistical analysis, lower microleakage and void scores were observed in group II. Higher microleakage and void scores were observed in group I.

The mean microleakage and void score of group I is higher compared to other groups and the mean microleakage and void score of group II is lowest compared to other groups.

ONE WAY ANOVA WITH POST HOC TUKEY TEST

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum	p-value
MICRO LEAKAGE	GROUP 1 (restored with packable composite)	10	2.10	.876	.277	1.47	2.73	1	3	0.002 * significant
	GROUP 2 (restored with flowable(cured) and then packable)	10	.50	.707	.224	-.01	1.01	0	2	
	GROUP 3 (restored with flowable and packable and then cured together)	10	1.50	1.080	.342	.73	2.27	0	3	
	Total	30	1.37	1.098	.200	.96	1.78	0	3	
INTERNAL VOIDS	GROUP 1 (restored with packable composite)	10	1.40	1.174	.371	.56	2.24	0	3	0.609
	GROUP 2 (restored with flowable(cured) and then packable)	10	.90	1.101	.348	.11	1.69	0	3	
	GROUP 3 (restored with flowable and packable and then cured together)	10	1.30	1.252	.396	.40	2.20	0	3	
	Total	30	1.20	1.157	.211	.77	1.63	0	3	

Post Hoc Tests

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) GROUP	(J) GROUP	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
MICRO LEAKAGE	GROUP 1 (restored with packable composite)	GROUP2 (restored with flowable(cured) and then packable)	1.600*	.403	.001	.60	2.60
		GROUP3 (restored with flowable and packable and then cured together)	.600	.403	.312	-.40	1.60
	GROUP 2 (restored with flowable(cured) and then packable)	GROUP1 (restored with packable composite)	-1.600*	.403	.001	-2.60	-.60
		GROUP3 (restored with flowable and packable and then cured together)	-1.000*	.403	.050	-2.00	.00
	GROUP 3 (restored with flowable and packable and then cured together)	GROUP1 (restored with packable composite)	-.600	.403	.312	-1.60	.40
		GROUP2 (restored with flowable(cured) and then packable)	1.000*	.403	.050	.00	2.00
INTERNAL VOIDS	GROUP 1 (restored with packable composite)	GROUP2 (restored with flowable(cured) and then packable)	.500	.526	.614	-.81	1.81
		GROUP3 (restored with flowable and packable and then cured together)	.100	.526	.980	-1.21	1.41
	GROUP 2 (restored with flowable(cured) and then packable)	GROUP1 (restored with packable composite)	-.500	.526	.614	-1.81	.81
		GROUP3 (restored with flowable and packable and then cured together)	-.400	.526	.730	-1.71	.91
	GROUP 3 (restored with flowable and packable and then cured together)	GROUP1 (restored with packable composite)	-.100	.526	.980	-1.41	1.21
		GROUP2 (restored with flowable(cured) and then packable)	.400	.526	.730	-.91	1.71

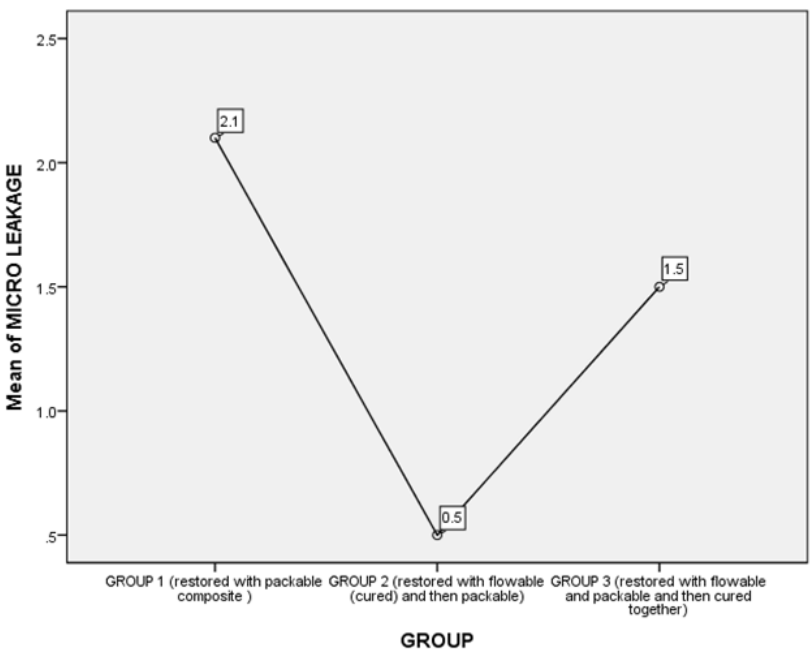
*. The mean difference is significant at the 0.05 level.

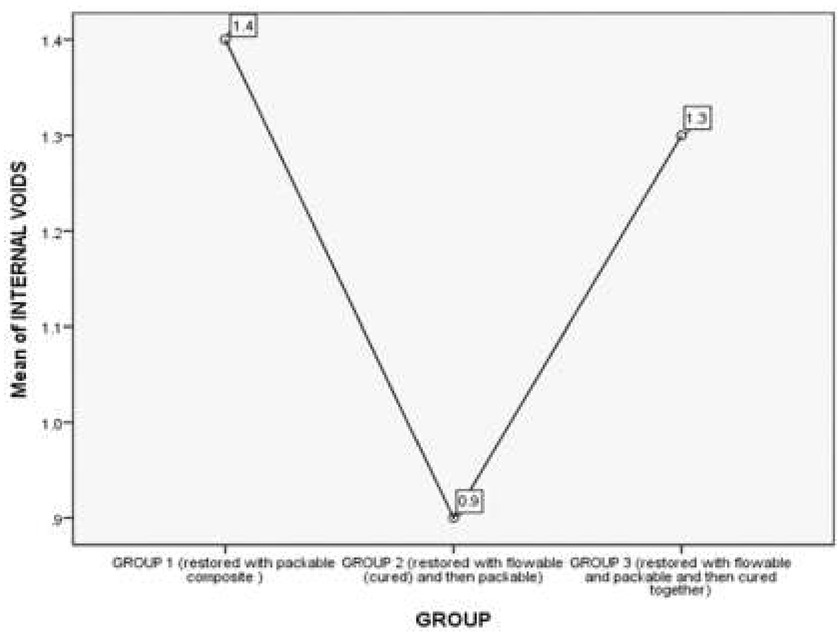
As per the CDs the mean microleakage and void score of group II is significantly lower than group III and group I (P=0.05). The P value is not falling into the confidence interval.

At an individual level, there is significant difference in the mean microleakage and void scores of group II and group I. The p=0.005 which is not in the confidence interval of (p>0.05).

DISCUSSION

The C-factor is the relationship between the number of bonded surfaces and the number of unbonded surfaces in a restoration (Kanca & Suh, 1999). The lower the C-factor, the lower the internal stresses. When the internal stresses are low, there is less competition between the contraction forces arising from monomer conversion and the efforts of the adhesive agent to keep the composite bonded to the surface (Tung & others, 2000).[1,2] The porosities reduce the relation between the adhering/non-adhering surfaces (Factor C), because the oxygen present in the porosities impairs the polymerization of the resin that contacts it so that this subpolymerized mass could flow around and compensate for the contraction with less stress.[3,4] However, these mechanisms were not sufficient to avoid the formation of gaps mainly at the cementum margins (Beznos, 2001; Hilton, Schwartz & Ferracane, 1997). When the margins were located below the CEJ, none of the techniques demonstrated a good sealing capacity. Based on in vitro studies with similar





results, some authors do not recommend direct composites when the margins are located below the CEJ, as inlays have shown a better sealing capacity (Puy& others, 1993; Dietschi& others, 1995).[5,8]

However, Van Dijken, Horstedt and Waern (1998) reported that even with margins below the CEJ, Class II composites showed excellent adaptation.[9]

This study also obtained good results with flowable composites. In this study, there were statistical differences among the groups but there was a clear tendency for better results with the flowable technique.

With the development of dentin bonding systems and the continuous improvement in material technology, resin based composite is superior to amalgam in terms of superior esthetics, reliable bonding to dental tissues, comparable compressive strength, improved wear resistance and no mercury.[11]

However, inspite of having many ideal properties, it has certain disadvantages which include polymerization shrinkage, contraction stress and increased likelihood of impaired marginal sealing. Moreover characteristics such as moisture sensitivity, lack of condensing ability, and stickiness to instruments may worsen the cavity adaptation of composite restorations.[13] Polymerization shrinkage occurring during composite curing induces stresses at the tooth restoration interface resulting in gap formation leading to marginal leakage. The inherent differences in coefficient of thermal expansion between composite resin and the tooth structure also contribute to marginal leakage.[14,15] Microleakage is most significant disadvantage associated with the use of composite restorative materials. It is dependent upon several factors including adaptation of resin material to tooth surface, the bonding material used, the technique of bonding, polymerization shrinkage and thermal stability of material. [16,17]

Microleakage may provoke sensitivity due to interfacial hydrodynamic phenomenon and can lead to colonization of microorganisms and high incidence of secondary caries and may clinically cause restoration failure.[18]

Restoration of class II cavities with packable composites still remain a controversy with respect to its marginal adaptation in proximal box region and literature has shown that when packable composites are placed apical to CEJ, there is higher marginal leakage from dentin gingival margins, when compared to the cavities placed coronal to CEJ.[19] Although packable resins do not stick to dental instruments, they were difficult to adapt to cavity preparation due to their stiffness.[20] So application of a cavity liner in areas of difficult access or flow was thought to reduce microleakage. Packable composite was developed by changing the filler or matrix phase to increase viscosity for better condensation similar to that of amalgam. However ability to adequately adapt the internal areas was always questionable leading to microleaklage and voids. Voids and gingival marginal areas can result from the inability to adequately adapt the materials to margins before curing. Condensable composites with high viscosity may increase the possibility of internal voids.[21] So in an attempt to reduce the voids, various incremental techniques, curing techniques and lining materials have been designed. The flowable composites are less viscous materials due to which it flows easily and adapts well to the tooth surface resulting in less leakage and postoperative sensitivity.[22] They also serve as flexible intermediate layer which absorb stress during polymerization shrinkage of composite resin. Flowable composites shrink more because they have less filler loading, so they were applied as a thin liner of 1mm thickness to minimize the effect.[23,24] A cavity liner acts as a stress breaker, reduces C-factor, has good flow due to low viscosity, and decreases the bulk of the overlying packable composite. Flowable composites shrink more because they have less filler loading, so they were applied as a thin liner of 1mm thickness to minimize the effect.[25] Most of flowable composite is expelled while placing overlying composite and its volume will be minimized. This technique offers the advantage of two different composites including intimate adaptation of filling and handling properties.[26] An advantage of flowable composites is their lower Young's Modulus in comparison with other hybrids. This could contribute to the dissipation of contraction stresses during polymerization.Vedavathi Bore Gowda et al, concluded that precured flowable composite liner is more effective in sealing the gingival cavosurface margins of class II preparation compared to other groups.[27] Rajesh Arora et al, in his study concluded that there is less microleakage in enamel margin than dentin margin and there is no need for placing liner below class II, because placing liner does not have significant effect on microleakage when margins were placed in enamel. [28] A Ölmez et al, concluded that a composite lining in a Class II resin composite with margins below the cementoenamel junction may reduce marginal microleakage and voids in the interface and the total number of voids in the restoration. [29,30]

This study revealed that the use of flowable resin composites as a lining material should result in a reduction in the likelihood of the formation of voids and a reduction in marginal microleakage. As flowable composites are more resin rich, they have low viscosity and flow and adapt at least as well as resin composites.

CONCLUSION

Within the limitations of this study, it was concluded:

For marginal microleakage, Group II in which the samples that were lined with FILTEK Z350 XT (3M ESPE) composite resin and cured with LED light and restored with FILTEK P60 (3M ESPE) composite resin and cured with LED light, showed the best marginal integrity($p<0.05$).

Flowable resin composites were superior to resin composites in preventing microleakage, though the margins were below the cementoenamel junction ($p<0.05$)

For internal voids, Group II showed the least no of voids.

Therefore, according to this in vitro study it can be concluded that within the limitations of this study, it is preferable to cure the flowable composite liner separately followed by curing of packable composite to reduce microleakage and internal voids.

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