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A Comparative Study To Evaluate The Microleakage In Class V Cavities Restored With Recent Nano Hybrid Composites.

Dr Mrudhula Kamal[1], Dr Utkarsh Piyush Shah[2], Dr Roshan Sadiya[3]
([1]Department of Conservative Dentistry and Endodontics, G.D.C.R.I ,Bangalore, [2]Department of Conservative Dentistry and Endodontics, G.D.C.R.I ,Bangalore ,[3]Department of Conservative Dentistry and Endodontics, D.A.P.M R.V Dental College, Bangalore)
Corresponding Author: Mrudhula Kamal

Abstract
Background and Objective*: Major disadvantage of resin composite is polymerization shrinkage, which can result in marginal discrepancies leading to microleakage. The aim of this study is to assess the ability of three Nanohybrid Composite resins (Estelite Alpha, Brilliant™ NG, Estelite Sigma Quick) to prevent microleakage in Class V resin composite restorations.*
Methodology*: A Total of 60 sound extracted premolars were selected on which Class V cavities were prepared with occlusal margin in enamel and the gingival margin dentine/cementum. Teeth samples were randomly assigned into three groups (n = 20), after etching and bonding samples were restored with nanocomposites (Estelite Alpha, Brilliant™ NG, Estelite Sigma Quick) respectively.*
Specimens were thermocycled, immersed in Methylene blue dye, sectioned longitudinally and analyzed for leakage at the occlusal and gingival interfaces. Kruskal–Wallis test, followed by Dunn's post hoc Test was used to determine the intergroup and intragroup difference and Mann–Whitney U test was used to determine the significant difference at enamel and dentin/cementum margin.
Results: *At occlusal margin group II and group I show statistical significant difference ($p<0.05$). At gingival margin group I and group III show statistical significant difference ($p<0.05$). Intra group comparison showed no statistically significant differences.*
Conclusion*: Within the limitations of this study, none of the three materials were free from microleakage.*
Keywords*: Acid etching, Cementum, Composite resin, Dentin, Enamel, Nano-hybrid*

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I. Introduction

Esthetics has become the prime requirement in the current world. From the perspective of dental restorations, along with providing esthetics, strong bonding is also a concern. Longevity of any restoration defines its clinical success.[1]

Resin-based composite materials are prominent aesthetics restorative materials because of their universal usage, minimal loss of tooth structure and no laboratory processing, also the superior mechanical and aesthetic qualities have made composites most widely used tooth-colored direct restorative materials in modern dentistry. [2,3] But, polymerization shrinkage still continues to be a problem.[4,5] This can result in impaired marginal seal providing access to bacteria, oral fluids, molecules and ions at the preparation walls/restorative material interface.[6,7] This in turn leads to staining at the margins of the restorations, recurrent caries at the tooth preparation walls and restorative material interface, hypersensitivity of the restored teeth and development of pulpal pathology[8] all of which endanger the longevity of the restoration.[9]

Many strategies have been used to diminish the negative effects of polymerization shrinkage in resin based composites, by changing the type of fillers or filler size, placing a thicker adhesive layers and using incremental placement techniques.[10,11]

Developments in filler technology and initiator systems have considerably improved composite physical properties and expanded clinical applications[11]. Nano filled materials are believed to offer excellent wear resistance, strength and ultimate esthetics due to their excellent polish ability, polish retention and lustrous appearance[12].

Brilliant NG, a universal composite which has prepolymerized particle filling, in addition to high nanometric particle content that produces decrease in shrinkage and easily achievable high gloss surfaces. Estelite group is supra nano monodispersive spherical particle composite with Estelite Alpha being launched recently. The spherical filler particles are uniformly dispersed and manufactured by the solgel method. Estelite sigma quick along with supra nanoparticles also has a special Radical Amplified Photopolymerization initiator (RAP technology).[1]

This study aims to assess the ability of the above mentioned recent nano-hybrid composite resins in preventing microleakage for Class V restorations and to compare the efficacy of these composite resins bonding to enamel as well as dentine/cemental margins.

II. Materials And Methodology:

This in-vitro study was conducted in the Department of Conservative Dentistry and Endodontics, Government Dental College and Research Institute, Bengaluru.

Selection criteria for the samples:

Sixty freshly extracted human maxillary premolar teeth extracted for orthodontic purpose

- Inclusion criteria**:** Non carious human premolars extracted for orthodontic reasons.
- Exclusion criteria**:** Previously cervically restored teeth, teeth with visible cracks, teeth with cervical caries, teeth with cervical abrasion, teeth with developmental defects.

All selected sixty teeth were cleaned to remove calculus and stains. The teeth were stored in 0.9% normal saline to prevent dehydration till further period of study.

Restorative Materials Used

Brilliant™ NG (ColteneWhaledent) nanaocomposite.
Coltène Etchant Gel Switzerland
One Coat Bond SL ,ColtèneWhaledent, Switzerland
Estelite Alpha (Tokuyama) nanaocomposite.
Palfique bond (single component self etching adhesive, tokuyama, Japan)
Estelite Sigma Quick (Tokuyama) nanaocomposite.

Preparation of Specimens:

The procedure for cavity preparation and restoration was standardized for all groups and performed by a single operator to minimize experimental variables.

A standardized Class V cavity preparation was done on the buccal surface of each tooth with an airotor handpiece using a coarse-grit cylinder diamond bur under air-water cooling. The dimensions of the preparations measured 5mm mesiodistally, 3mm occlusogingivally and 2mm depth with the occlusal margin in enamel and the gingival margin in dentin/cementum. A William's graduated periodontal probe (Hu-friedy, Chicago, IL, USA) was used to gauge the dimensions of the cavity. The teeth were then randomly divided into three experimental groups, each group containing 20 teeth.

Group I teeth were etched (Coltène Etchant Gel Switzerland) and bonded (One Coat Bond SL ,ColtèneWhaledent, Switzerland) according to manufacturer's instructions, restored with Nano composite (Brilliant^{TM} NG, colteneWhaledent, Switzerland) cured for 30 seconds with a LED curing light.

In Group II and group III, Bonding (Palfique bond, single component self etching adhesive, tokuyama, Japan) done according to manufacturer's instructions, cavities were restored with Estelite Alpha (Tokuyama, Japan) and LED light cured for 30 seconds and Estelite Sigma Quick (Tokuyama, Japan), light cured for 20 seconds respectively

All the restorations were contoured with finishing bur and finishing of the restoration was done using finishing points (SHOFU) with air-water spray in a high-speed hand piece.

Teeth were then stored in distilled water at 37°C. The specimens were subjected to a thermocycling regimen of 600 cycles between 4°C and 55°C waterbaths. Dwell time was one minute, with a three-second transfer time between baths.

Determination of marginal leakage

The specimens were coated with two layers of nail varnish, leaving a 1 mm window around the cavity margins. During the process of placement of nail varnish, a moist cotton pellet was placed over the restoration to prevent desiccation. Teeth were placed in methylene blue dye (Spectrum Reagents And Chemicals Pvt Ltd, Edayar, Cochin) for 24 hours. After removal of the specimens from the dye , the surface-adhered dye was rinsed in tap water .

The teeth were then sectioned longitudinally in a bucco-lingual direction through the center of the restorations using a low-speed diamond disc (Horico, Berlin, Germany). The sections were scored according to the criteria and evaluated with a stereomicroscope at 10x magnification to determine the extent of dye penetration at the occlusal and gingival margins.

Scoring criteria. The depth of the dye leakage was judged according to the following scale:

score 0: No dye leakage
score 1: Dye penetration less than half of the cavity preparation

score 2: Dye penetration more than half up to full cavity depth.

sample size estimation: For comparison of the microleakage in class V cavities restored with three different newer nano composites, minimum sample needed were 10 in each group, with the power of test 0.80, α=0.05 with 95% confidence interval. Hence, calculated sample size was 20.

III. Results

The Data collected by experiments were computerized and analyzed using Statistical Package for Social Sciences (SPSS) version 23.0. The mean and standard deviation of micro leakage in millimeters in all three study groups will be compared using A non-parametric Analysis of Variance test(Kruskal–Wallis) followed by Dunn's *post-hoc* Test and Mann–Whitney *U* test to determine the significant difference at enamel and cementum margin. A probability value of <0.05 will be considered to be statistically significant.

Null Hypothesis: There is no significant difference in the score between the groups i.e. $\eta_1=\eta_2=\eta_3$

Alternate Hypothesis: There is a significant difference in the score recorded between the groups i.e. $\eta_1\neq\eta_2\neq\eta_3$

Level of Significance: $\alpha<0.05$

Statistical test used: Kruskal–Wallis test, to determine the significant differences among the groups, followed by Dunn's post-hoc Test and Mann–Whitney U test.

Decision Criterion: Comparison of the p-Value with the level of significance. If $p<0.05$, the null hypothesis will be rejected and alternate hypothesis will be accepted. If $p\geq0.05$, then the null hypothesis is accepted.

Kruskal–Wallis test revealed that there was no statistical significant differences between group II and group III (P 0.05), group I and group III (P 0.05). Group I and group II (P 0.01) show significant difference. (Table 1) in microleakage at occlusal margins. And group I and group II (P 0.445), group II and group III (P 0.114) showed no significant difference, where as group I and group III (P 0.038) showed a statistically significant difference in microleakage at gingival margin. (Table 2).

There was no statistically significant difference found in dye leakage at occlusal and gingival margin among all three groups on performing Mann–Whitney *U* test (Table 3).

Out of three groups, group I showed highest mean microleakage at occlusal and gingival margin followed by group II. Whereas group III showed least microleakage both at occlusal and gingival margins. Null hypothesis was accepted as there was no statistically significant difference found among the groups at occlusal and gingival margins .

Table 1: Comparison of mean microleakage at occlusal margin

Groups	Group I	Group II	Group III
Mean(Mm)	0.99	0.77	0.45
SD	0.63	0.57	0.53
Group I	-		
Group II	P 0.01*	-	
Group III	P 0.05	P 0.05	-

Table 2: Comparison of mean microleakage at gingival margin

Group	Group I	Group II	Group III
Mean(mm)	2.0	1.10	1.83
S D	0.00	0.74	0.44
Group I	-		
Group II	P 0.445	-	
Group III	P 0.038*	P 0.114	-

Table 3: Intra group comparison of microleakage at occlusal and gingival margin

Group	*P* value	Significance
Brilliant™ NG	0.58	Not significant
Estelite Alfa	0.55	Not significant
Estelite Sigma Quick	0.34	Not significant

SD- standard deviation, N- sample size

IV. Discussion

Microleakage is an important property that has been used in assessing the success of any restorative material used in restoring tooth [13]. Improvements in resin composites have increased their usefulness as restorative materials; however, polymerization shrinkage continues to remain one of the primary deficiencies of composite restorations. Polymerization shrinkage causes contraction stress within the restoration that leads to microleakage, as well as stress within the surrounding tooth structure.

Possible reasons for microleakage at the dentin restoration margin are cavity configuration (C-factor), dentinal tubule orientation to the cervical wall (CEJ), organic content of dentine substrate and movement of

dentinal tubular fluids, incomplete alteration or removal of smear layer by acidic primers (self-etch system) for adequate demineralization and hybrid layer formation, inefficient infiltration/ penetration of primer components into the demineralized collagen fibrils, dentin substrates hydration level, incomplete evaporation of the solvent from the dentin surface prior to attachment of the adhesive monomers, incompatibility of the bonding agent with the respective resin composite, acid component composition (pH, osmolarity, and thickening agent), polymerization contraction, physical characteristics of the restorative material, (filler loading, volumetric expansion, and modulus of elasticity), inadequate margin adaptation of restorative material, polymerization source-photoinitiator incompatibilities and instrumentation, and finishing and polishing effects. Cervical lesions have been a restorative challenge for any kind of restorative material due to their complex morphology where the margins are partly in enamel and partly in dentin/cementum. Hence the current study examined the microleakage of different composite resins placed in class V cavities using a dye penetration test.

Dye penetration method is the most frequently used method for detecting microleakage [14]. Methylene blue can diffuse easily through the interface and is easily detectable and is not absorbed by dentinal matrix apatite crystals. It also has low molecular weight thus has high penetrability[15].

Thermocycling regimen of 600 cycles between 4°C and 55°C water baths was carried out. Dwell time was one minute, with a three-second transfer time between baths.

One study stated that it is not only the degree of conversion that acts upon the polymerization shrinkage, but also the composition and structure of the material[16]. Kanika *et al.* conducted a study to evaluate microleakage of various restorative materials and concluded that nano filled composite showed least microleakage compared to other composites.[17] Ibrahim *et al.* in another study stated that among nano filled composite resins, nano-hybrid composites revealed less microleakage when compared to other composites due to their high filler content.[18]

Brilliant™ NG is a universal nano-hybrid composite with high nanometric particle content that produces optimum consistency for manipulation and less polymerization shrinkage and easily achievable high gloss surfaces.

Estelite group has supranano particles with a particle size of 0.2 μ and uniformly distributed in the matrix.They were prepared by a sol-gel method, which made them uniformly spherical. They were distributed evenly in the resin matrix.

Estelite Sigma Quick adopted a Radical Amplified Photopolymerization technology which provides it a fast curing cycle. It has supra nano monodispersing spherical filler, giving it better esthetics and ease of handling .[19]

The present study attempted to evaluate the microleakage of Class V cavities to determine the bonding capacity of the newer nano composites in both enamels as well as dentine/cemental area. The samples were scored by visual inspection with the use of stereomicroscope under 10X magnification.

According to the results of the study, group III (0.45±0.53) showed lowest mean microleakage at occlusal margin followed by group II (0.77±0.57), highest in group I (0.99±0.63). At gingivalmargins, Group III (0.63±0.50) showed lowest mean microleakage, followed by group II (0.95±0.51) and highest in group I (1.01±0.63).

The results for nanocomposite Brilliant™ NG showing higher microleakage scores at the occlusal and gingival margin may be explained by the filler content being only 80% by weight and thus increased the polymerization shrinkage (volumetric shrinkage by 2.2%) which could adversely affect marginal adaptation.

Because the average particle filler size of Estelite Sigma Quick is 200 nm, it is considered a supra-nano-fill composite. The low volumetric shrinkage i.e. 1.3% reduces marginal leakage and stress on the restoration-tooth complex[19].

The mechanism underline the performance of Estelite Sigma Quick showing least microleakage, can be attributed to different composition and the application protocol of the manufacturer. With the radical amplified photopolymerization initiator, the initial stage of camphoroquinone excitation by light is the same as in conventional systems. However, energy is transferred to the radical amplifier (RA); the radical amplifier is subsequently excited, then allowed to decompose to produce radical amplifier derived radicals. Theses radicals act as the polymerization initiator and react with monomers to generate polymers, producing the curing effect. Another advantage of Estelite Sigma Quick is that it is superior at diffusing light[19].

Many studies illustrated that the rate of volumetric polymerization shrinkage of Estelite Sigma Quick is significantly low leading to less microleakage, which support findings of the present study.[20,21] On comparison with other composite resins, the micro tensile bond strength of Estelite Sigma Quick with dentin is also good (51.0 Mpa).[22]

The mean microleakage was highest at gingival margin compared to occlusal margin in all groups. More amount of microleakage is seen in margins extending apical to cementoenamel junction. This can be attributed to the fact that when margins are placed in enamel dentin interphase, bonding to enamel is higher as enamel is a highly mineralized tissue, containing >90% hydroxyapatite crystals. Bonding to dentin is weak as

dentin has a heterogenous structure containing 70% inorganic, 18% organic & 12% water. Also cementum has less organic phase and coarser collagen fibres rendering it a weaker bonding substrate[23].

Group II and group I show statistical significant difference ($p<0.05$) at occlusal margin, Group I and group III show statistical significant difference ($p<0.05$) at gingival margin,Whereas Intra group comparison showed no statistically significant differences in dye leakage at occlusal margin and gingival among all groups($p>0.05$).

V. Summary

Within the limitation of this in vitro study it can be concluded that ,none of the tested materials were able to eliminate microleakage at occlusal or gingival margins in a class V cavity preparation. There was no statistical significance in microleakage among the groups. Within the experimental conditions of this in vitro study, the microleakage was lower at the occlusal margins than at the gingival margins for the three nanohybrid restorative materials tested. Estelite Sigma Quick performed better at both occlusal and gingival margin with least mean microleakage. Estelite Alpha performed better than Brilliant™ NG in both occlusal and gingival margin, but showed more microleakage than Estelite Sigma Quick. Brilliant™ NG showed the highest mean microleakage at both the margins of the cavity. Since Estelite Sigma Quick performed better at the occclusal and gingival margin compared to other tested material, it can be a good choice of restorative material for class V cavities. Clinical trials should be performed to assess the performance of these restorative materials before definitive conclusions are formulated.

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